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PATENT & TRADEMARK OFFICE

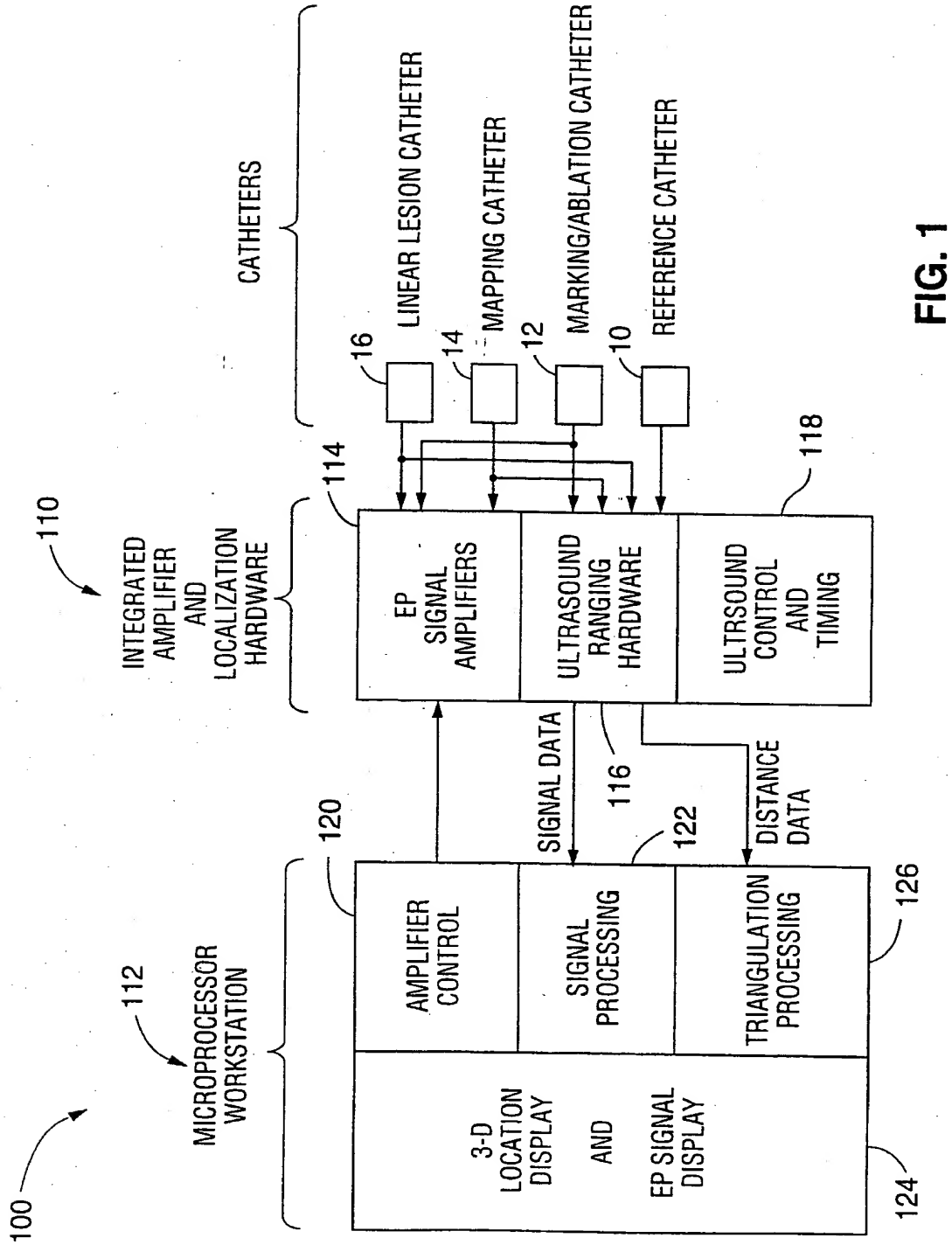

FIG. 1

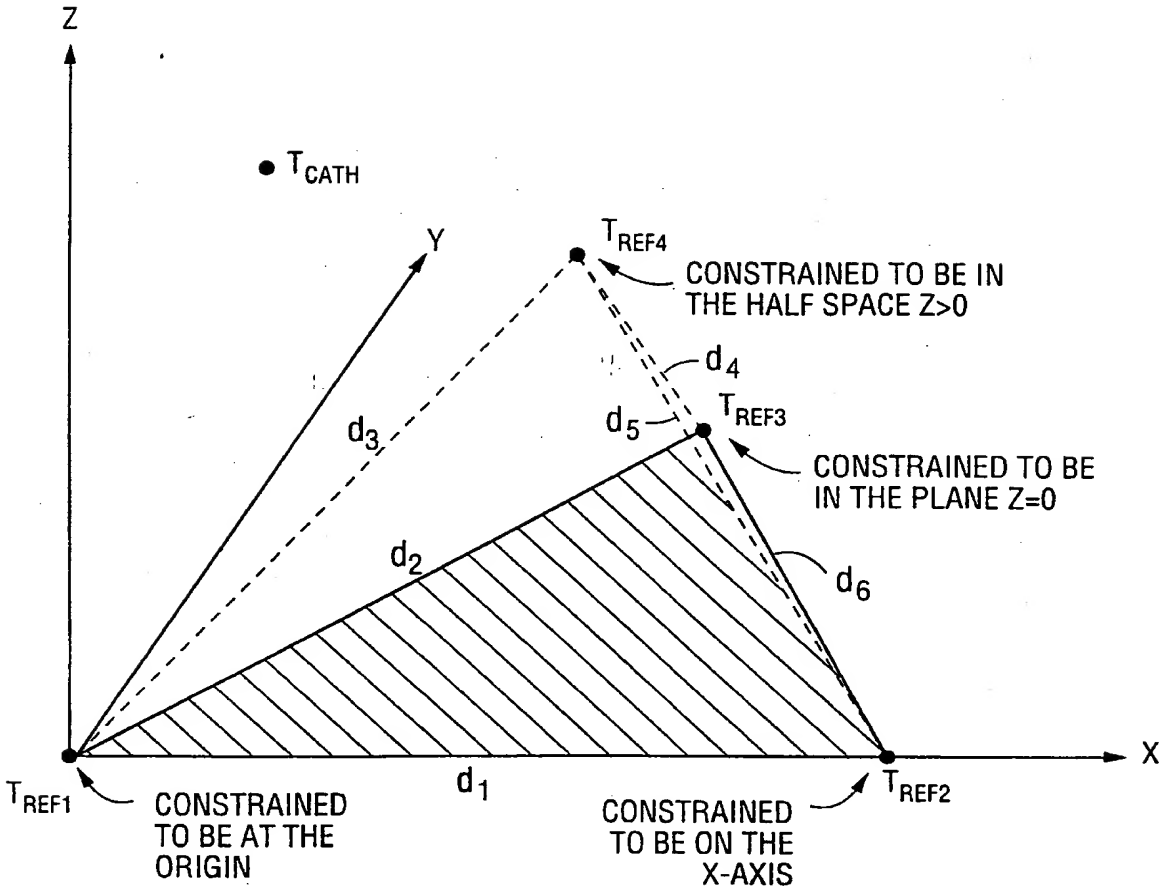
Z
Y
X
T_{CATH}
T_{REF1}
T_{REF2}
T_{REF3}
T_{REF4}
d_1
d_2
d_3
d_4
d_5
d_6
CONSTRAINED TO BE IN THE HALF SPACE Z>0
CONSTRAINED TO BE IN THE PLANE Z=0
CONSTRAINED TO BE AT THE ORIGIN
CONSTRAINED TO BE ON THE X-AXIS

FIG. 2

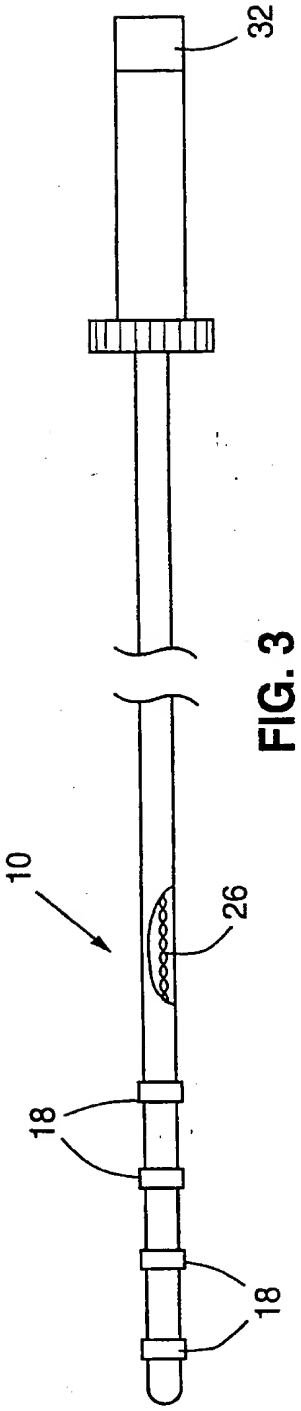

FIG. 3

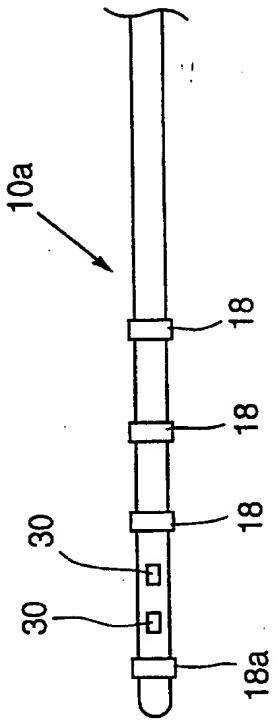

FIG. 4

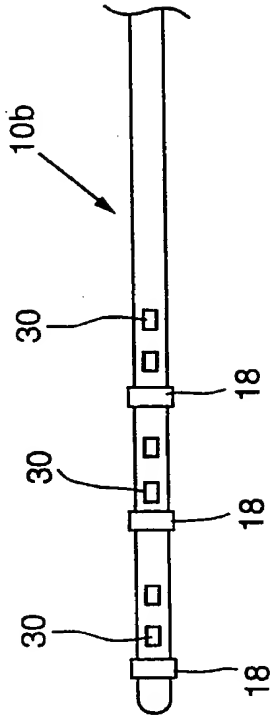

FIG. 5

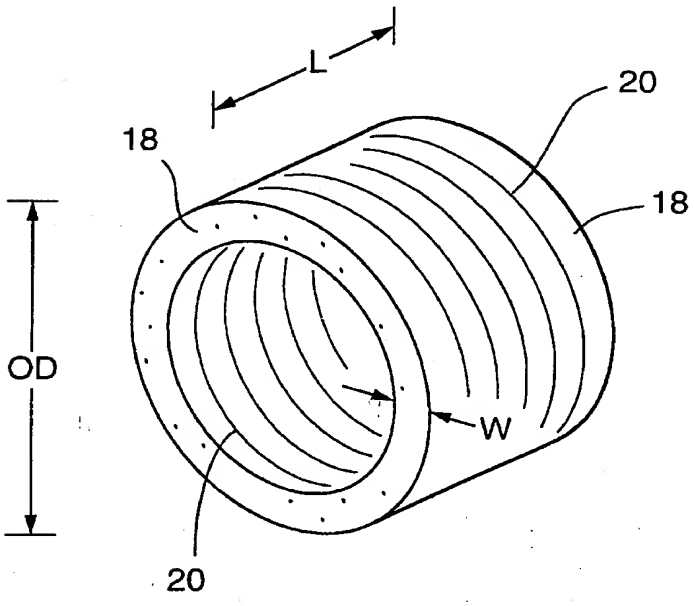

FIG. 6

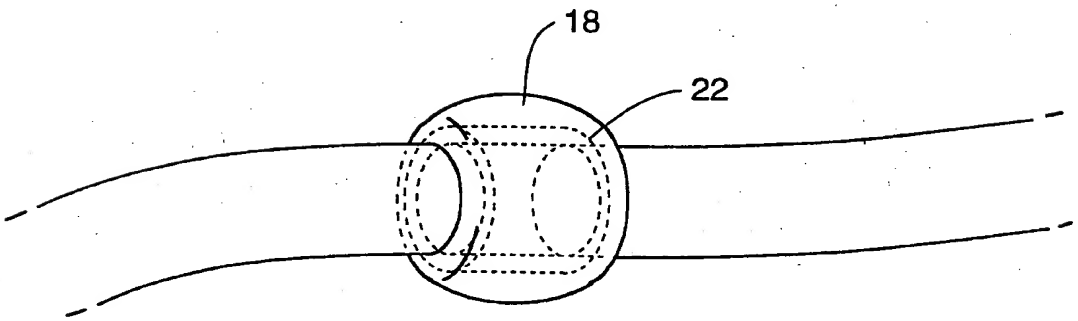

FIG. 7

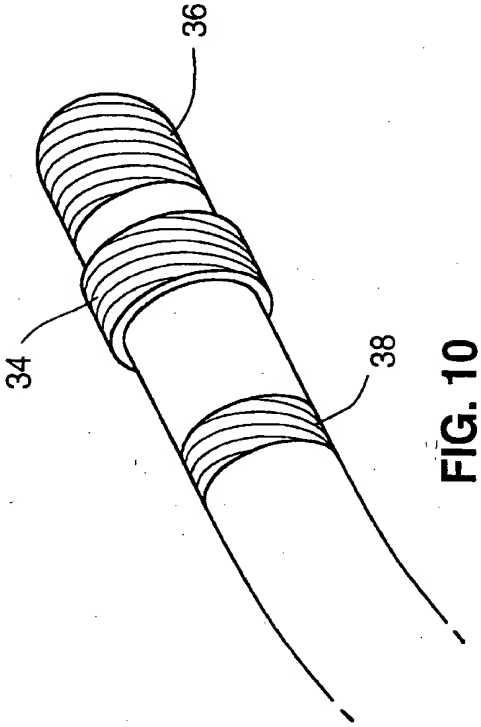

FIG. 10

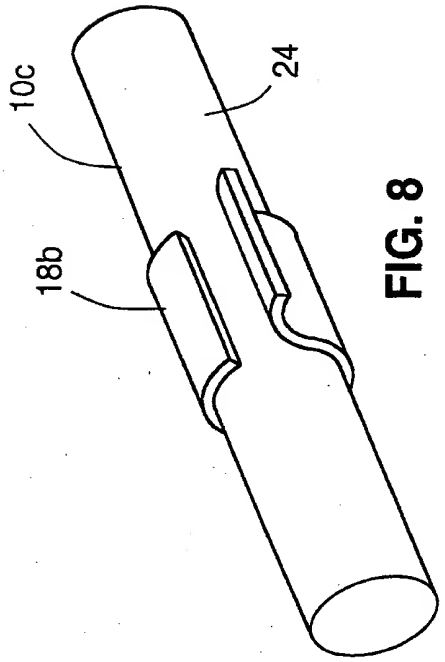

FIG. 8

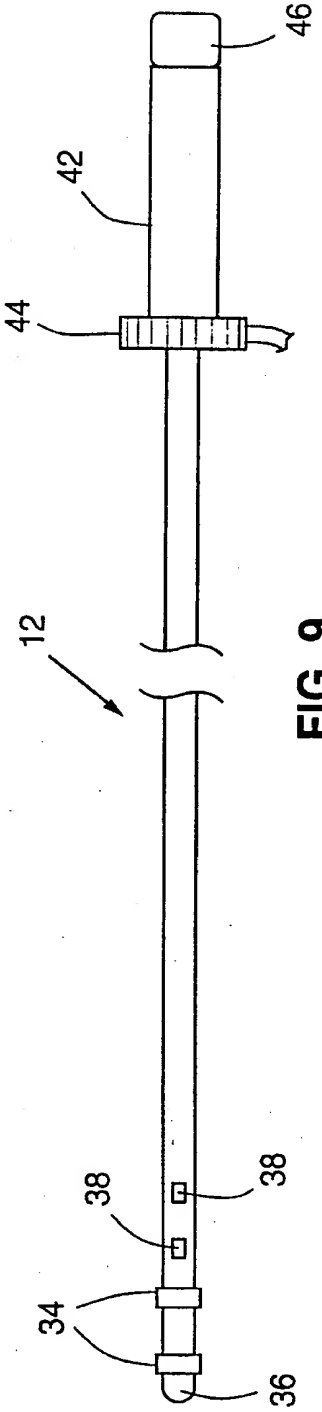

FIG. 9

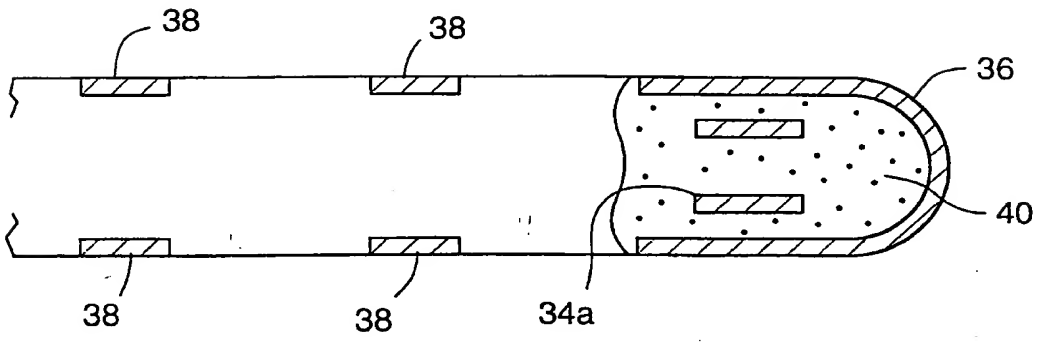

FIG. 11

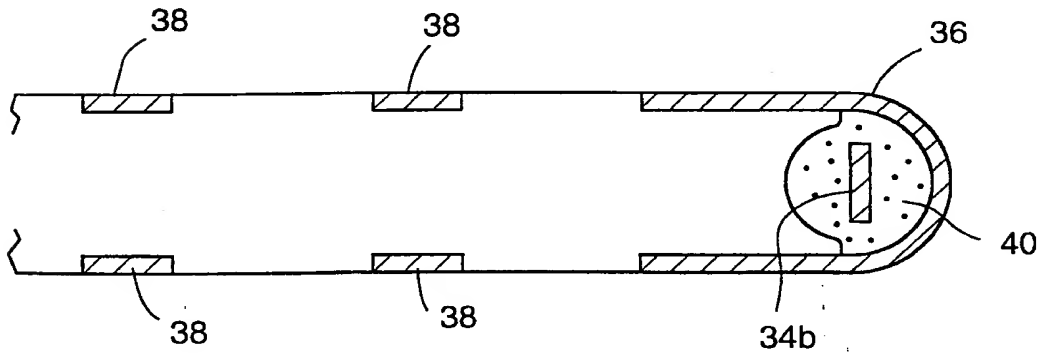

FIG. 12

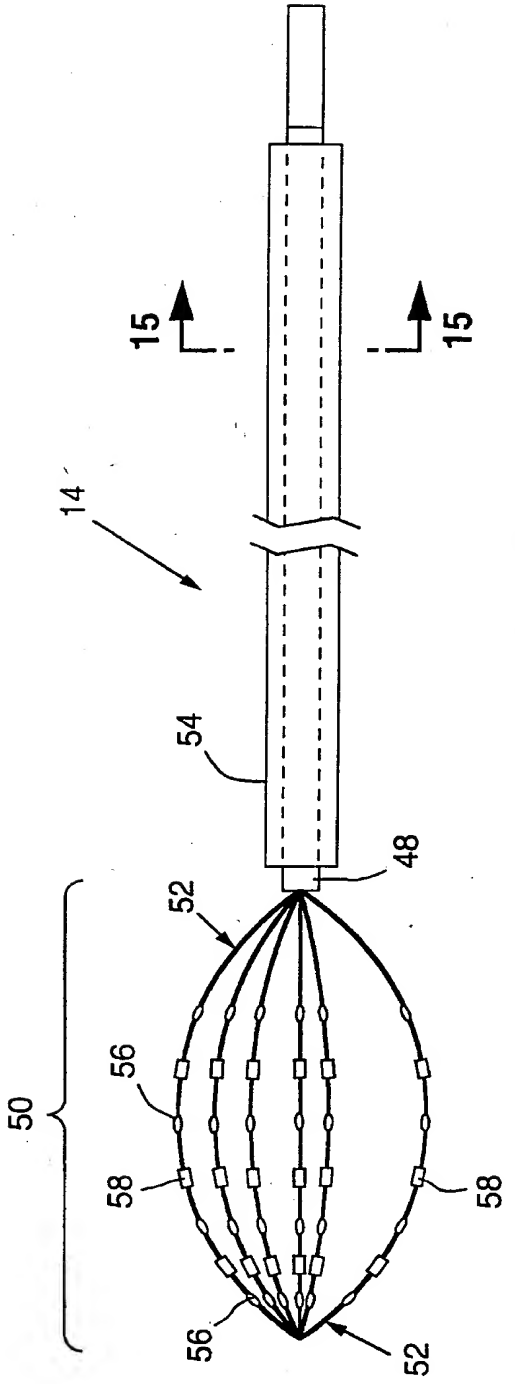

FIG. 13

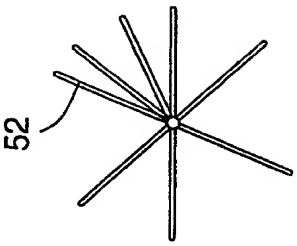

FIG. 14A

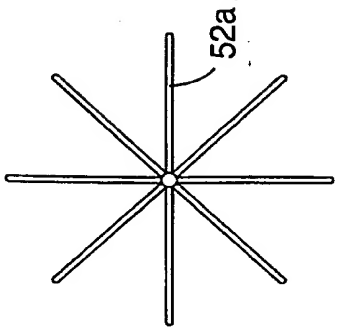

FIG. 14B

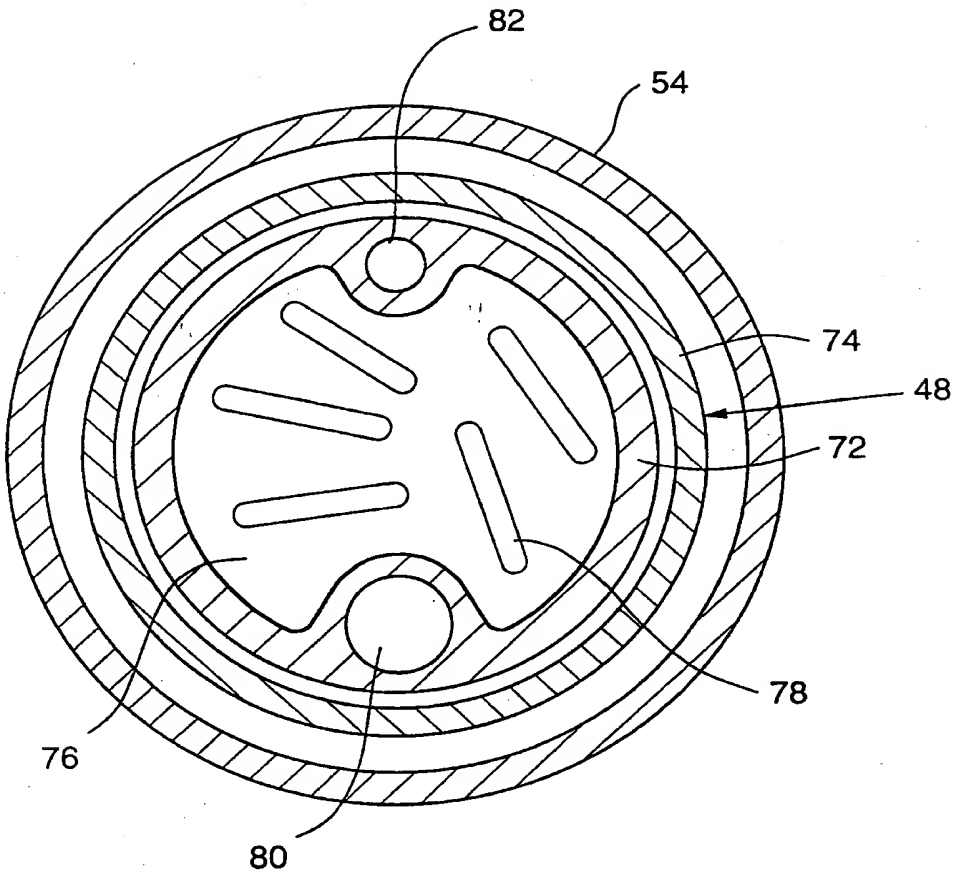

FIG. 15

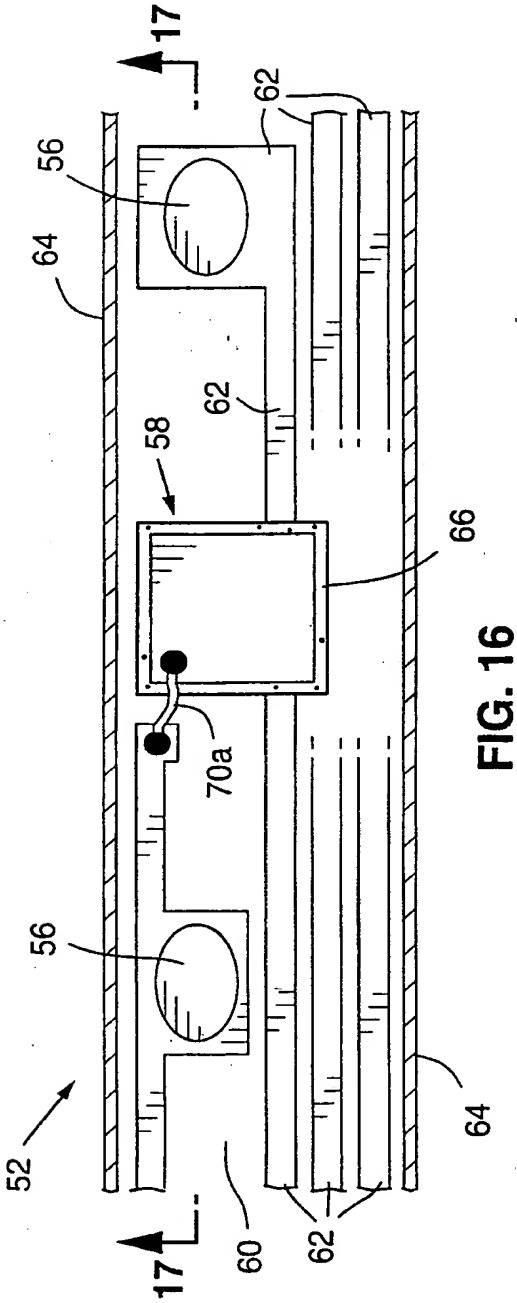
17
62
56
64
62
58
66
70a
56
52
60
62
64
17

FIG. 16

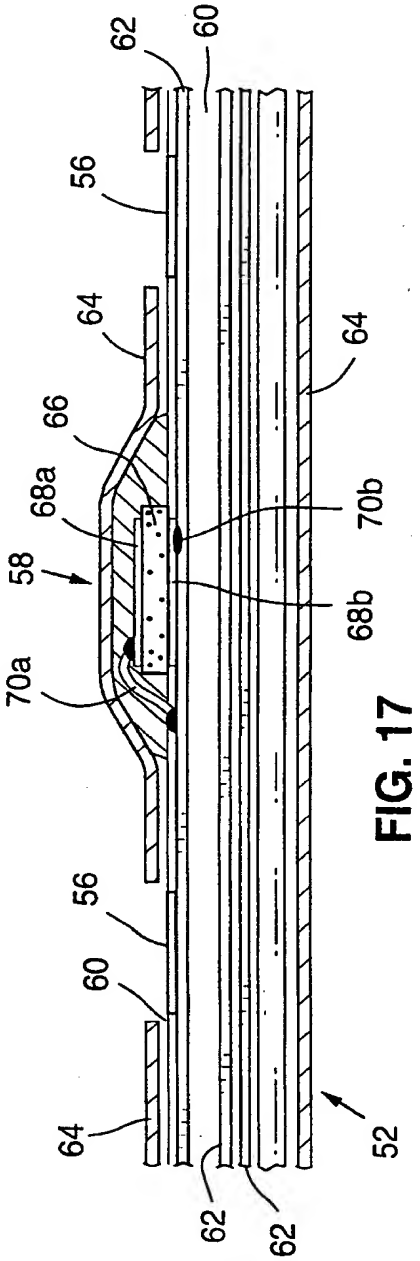
62
60
56
64
64
66
68a
70b
58
68b
70a
56
60
64
52
62
62

FIG. 17

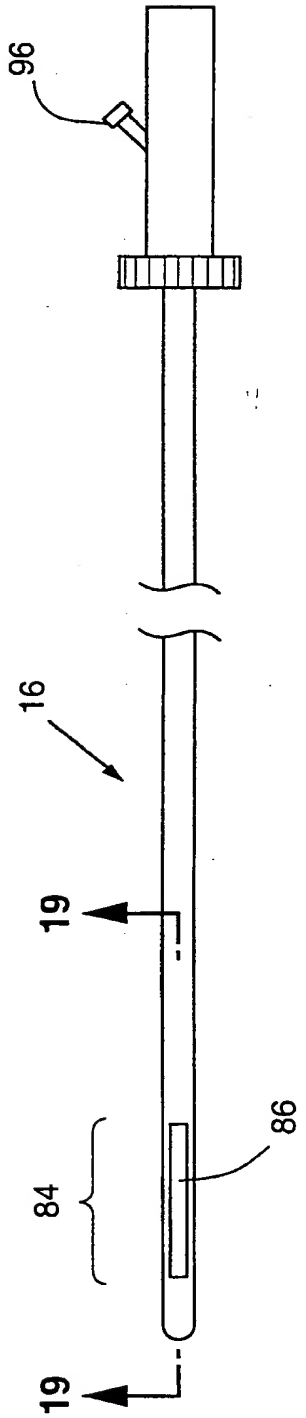

FIG. 18

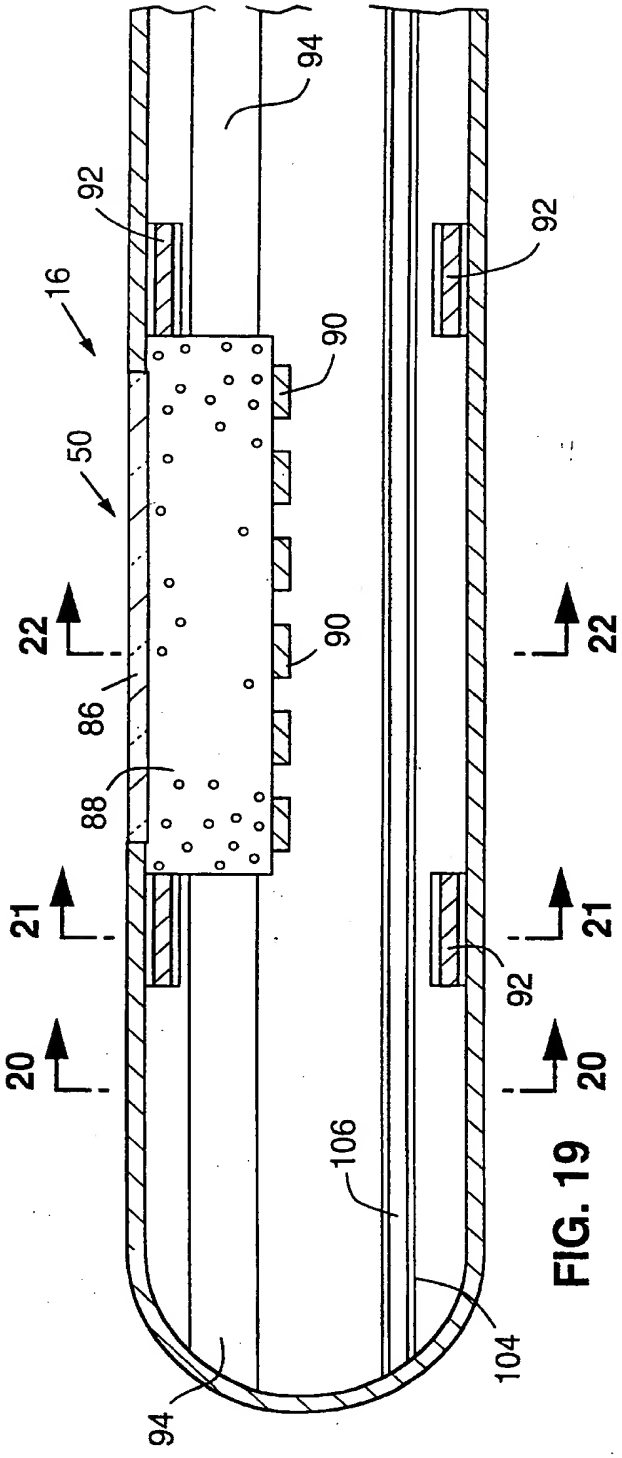

FIG. 19

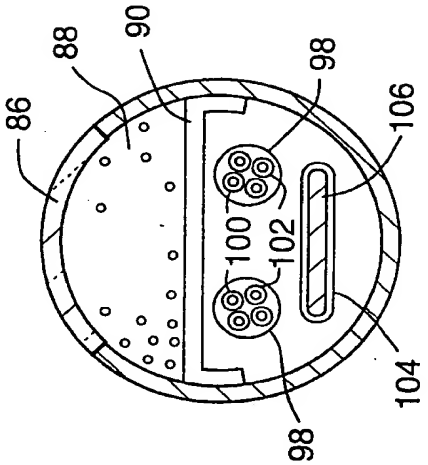

FIG. 22

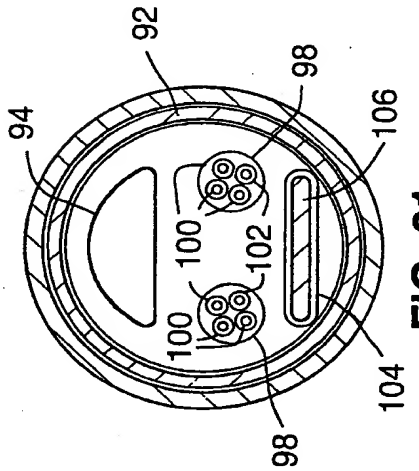

FIG. 21

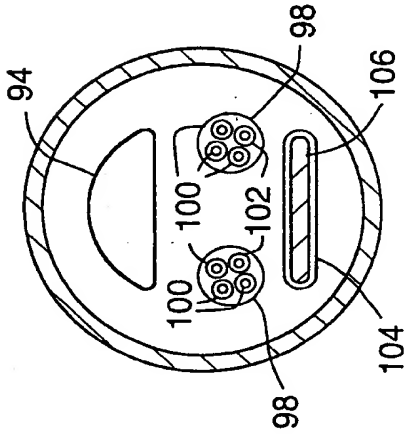

FIG. 20

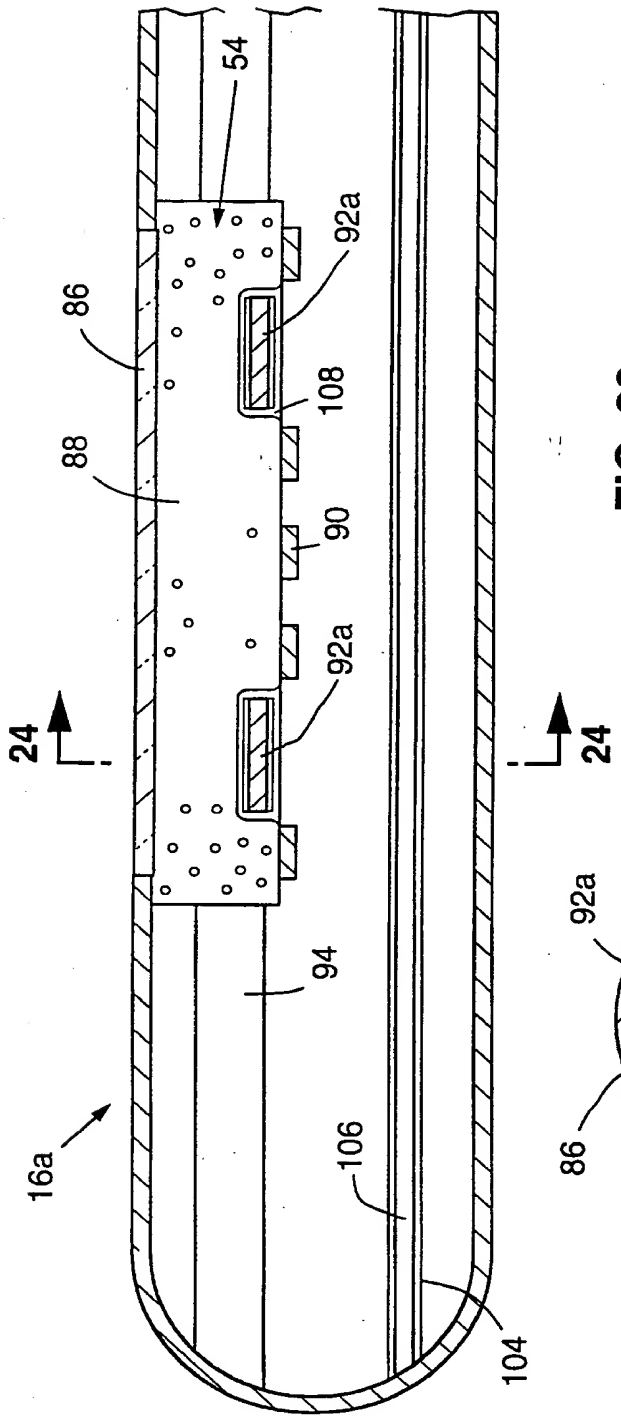
54
92a
86
108
88
90
92a
24
24
94
16a
106
104

FIG. 23

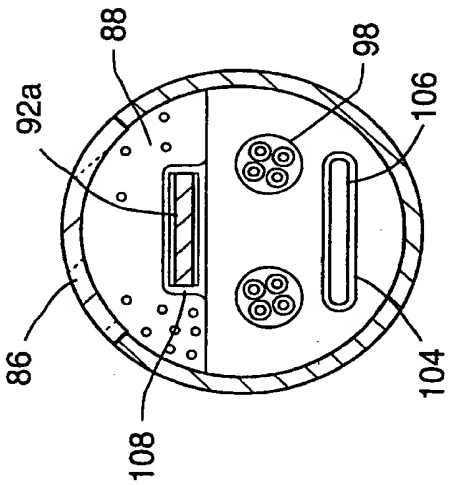
88
98
92a
106
86
104
108

FIG. 24

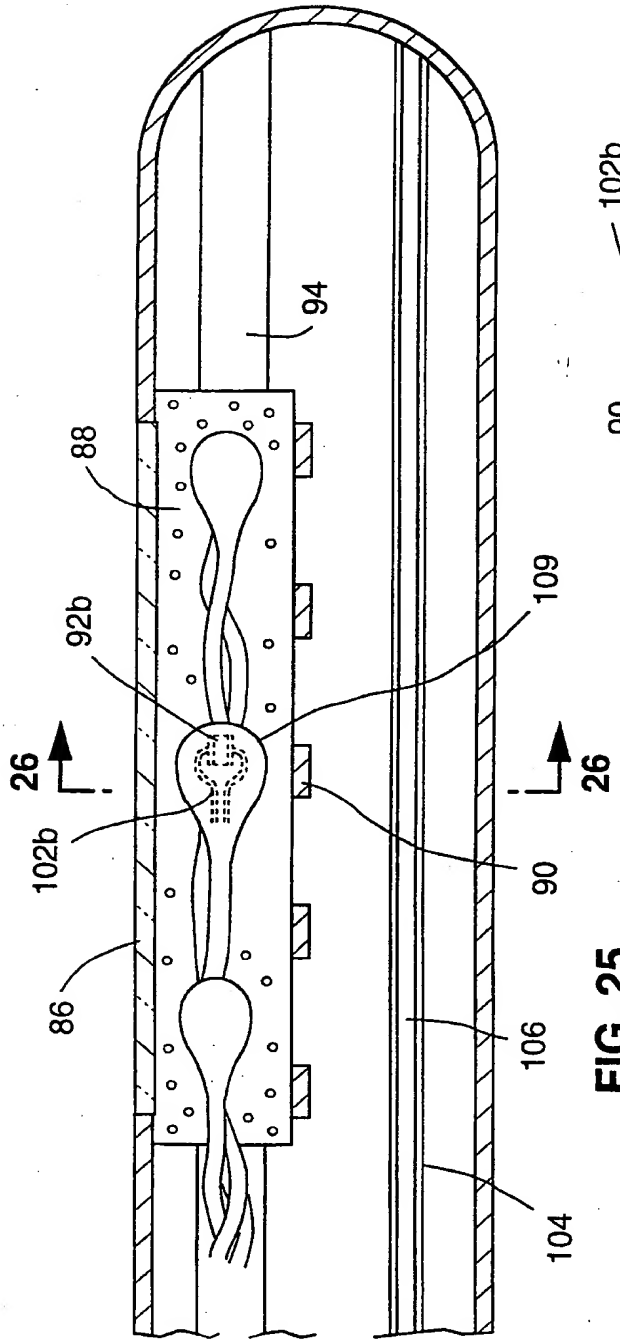

FIG. 25

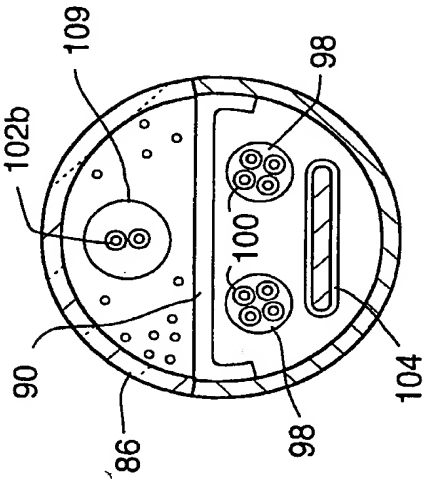

FIG. 26

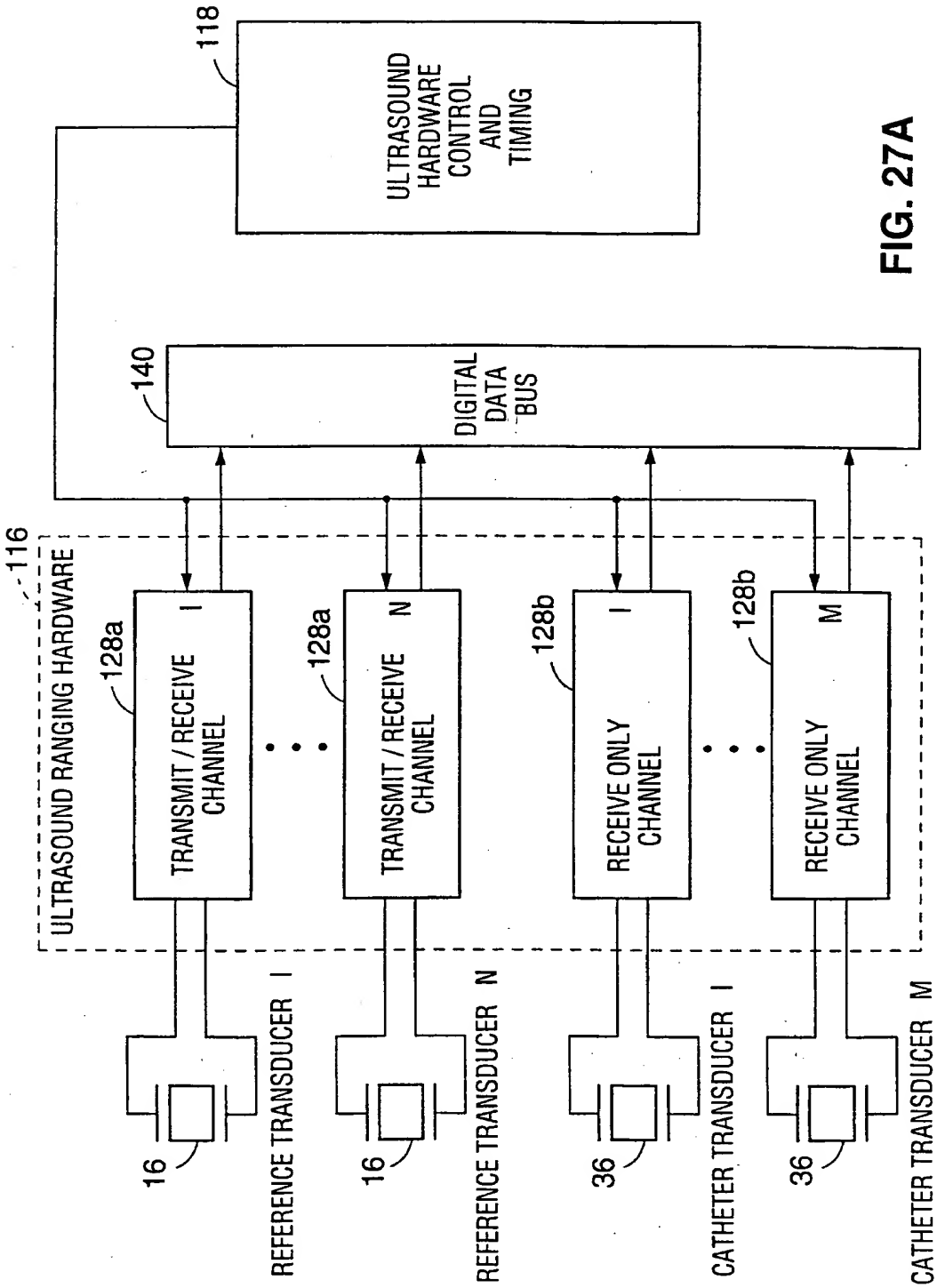
118
ULTRASOUND HARDWARE CONTROL AND TIMING
140
DIGITAL DATA BUS
116
ULTRASOUND RANGING HARDWARE
128a
1
TRANSMIT / RECEIVE CHANNEL
128a
N
TRANSMIT / RECEIVE CHANNEL
128b
1
RECEIVE ONLY CHANNEL
128b
M
RECEIVE ONLY CHANNEL
16
REFERENCE TRANSDUCER 1
16
REFERENCE TRANSDUCER N
36
CATHETER TRANSDUCER 1
36
CATHETER TRANSDUCER M

FIG. 27A

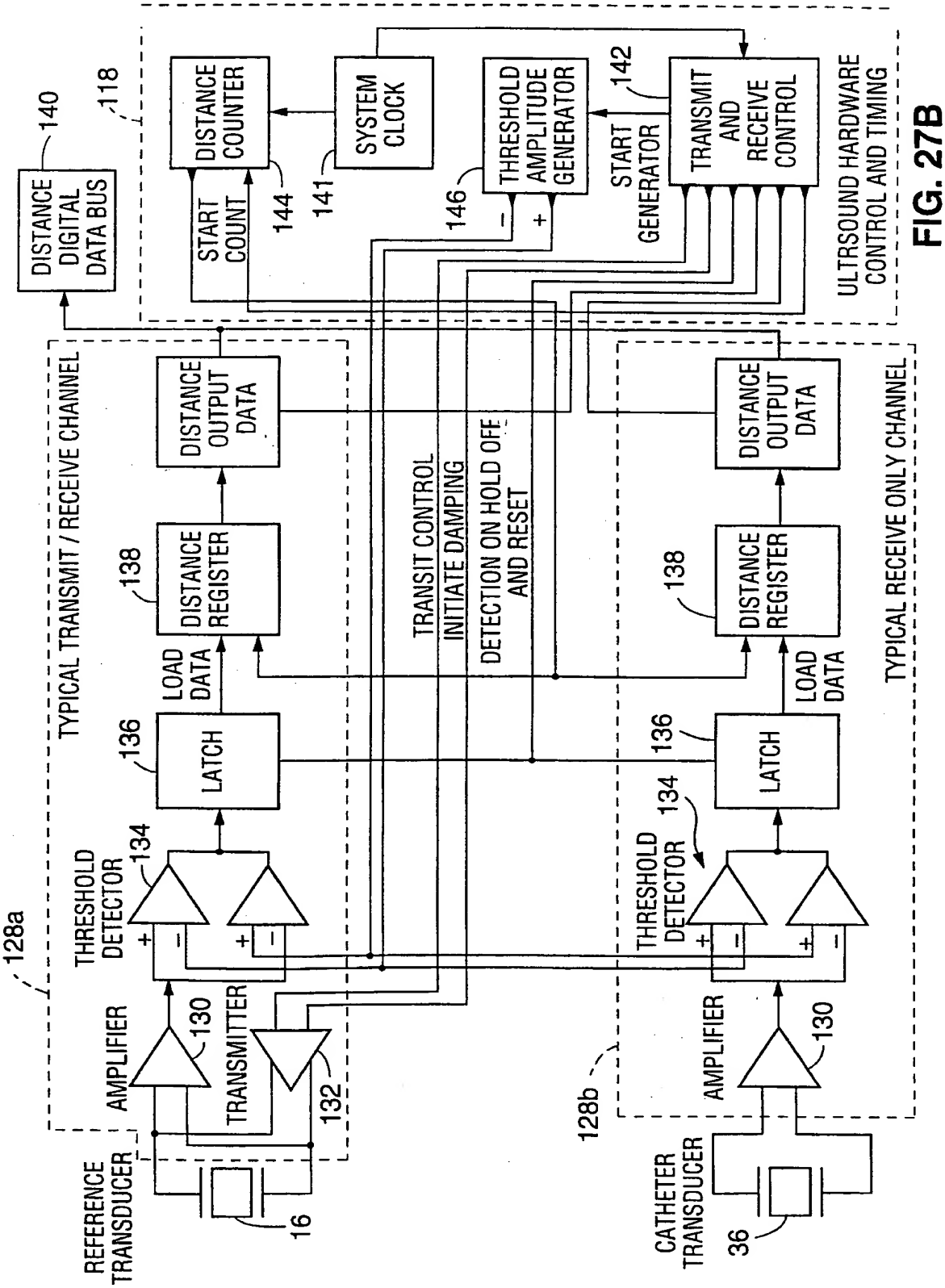
ULTRSOUND HARDWARE CONTROL AND TIMING
118
DISTANCE DIGITAL DATA BUS
140
DISTANCE COUNTER
START COUNT
144
SYSTEM CLOCK
141
THRESHOLD AMPLITUDE GENERATOR
146
START GENERATOR
142
TRANSMIT AND RECEIVE CONTROL
TRANSIT CONTROL
INITIATE DAMPING
DETECTION ON HOLD OFF AND RESET
TYPICAL TRANSMIT / RECEIVE CHANNEL
TYPICAL RECEIVE ONLY CHANNEL
128a
128b
DISTANCE OUTPUT DATA
DISTANCE REGISTER
138
LOAD DATA
LATCH
136
THRESHOLD DETECTOR
134
AMPLIFIER
130
TRANSMITTER
132
REFERENCE TRANSDUCER
16
CATHETER TRANSDUCER
36

FIG. 27B

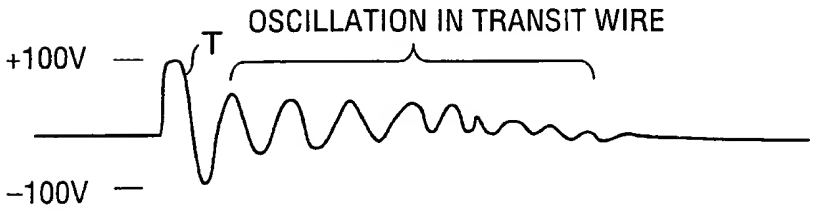

FIG. 28A

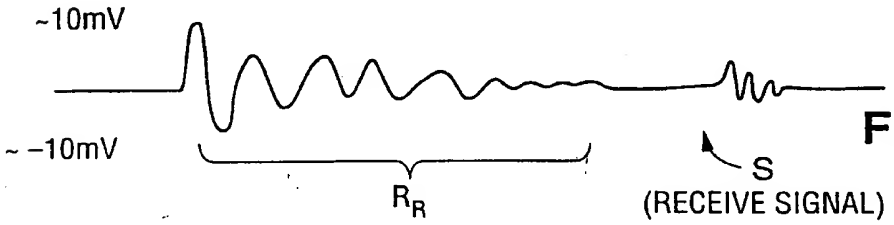

FIG. 28B

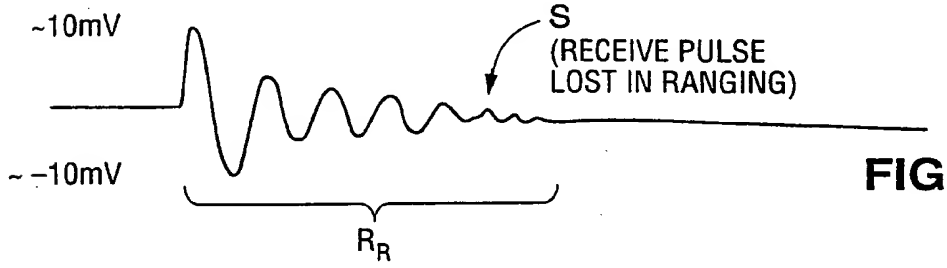

FIG. 28C

FIG. 28D

FIG. 28E

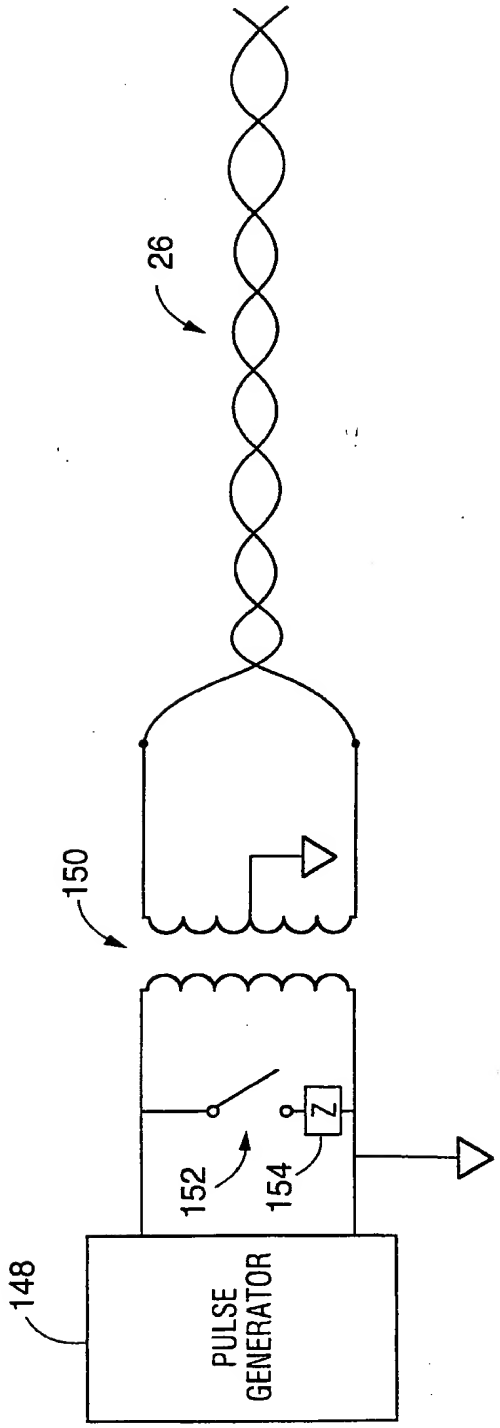

FIG. 29

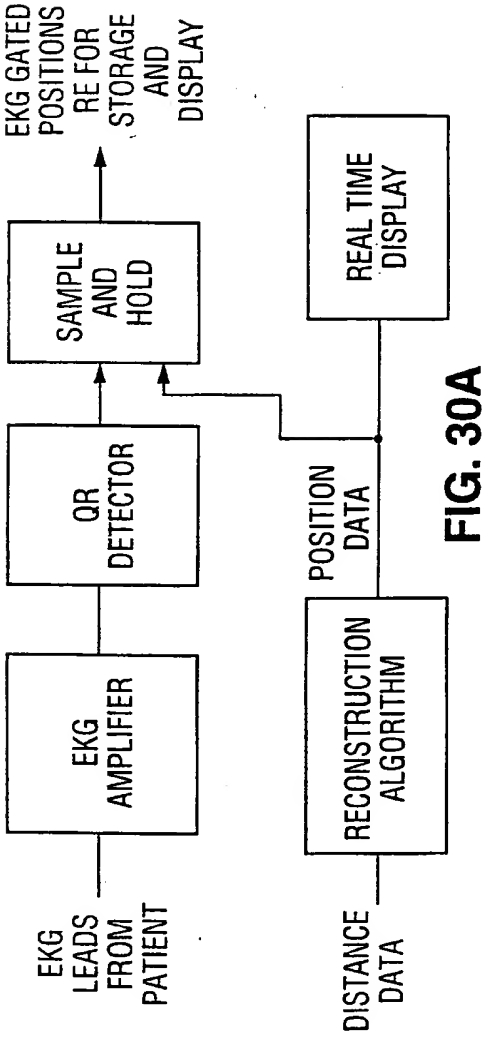

FIG. 30A

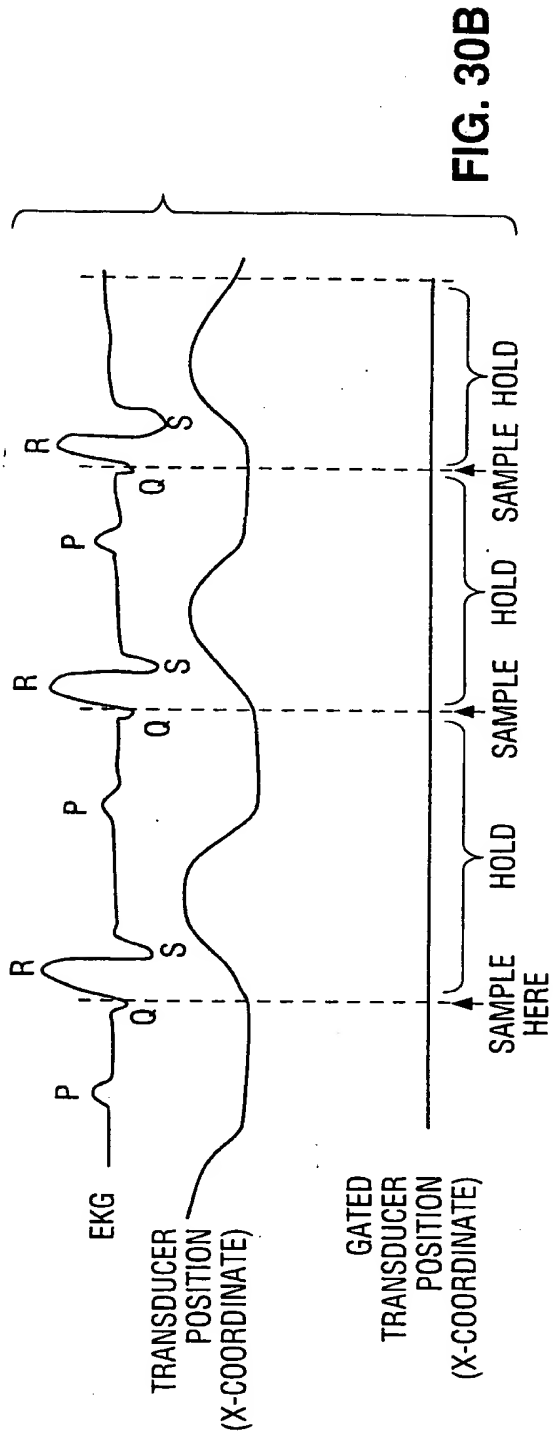

FIG. 30B

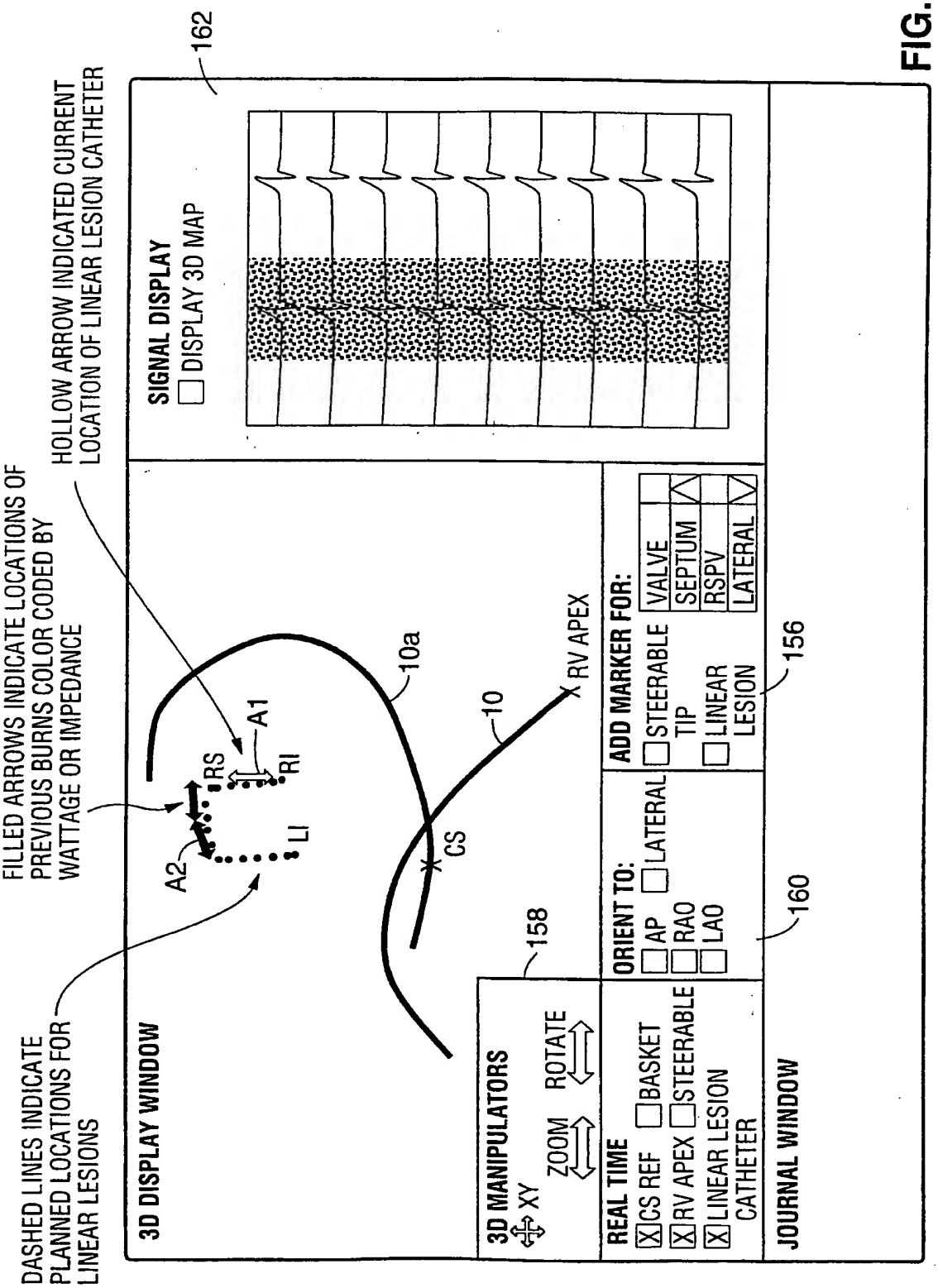
DASHED LINES INDICATE PLANNED LOCATIONS FOR LINEAR LESIONS
FILLED ARROWS INDICATE LOCATIONS OF PREVIOUS BURNS COLOR CODED BY WATTAGE OR IMPEDANCE
HOLLOW ARROW INDICATED CURRENT LOCATION OF LINEAR LESION CATHETER
3D DISPLAY WINDOW
A2
LI
RS
A1
RI
10a
10
CS
RV APEX
SIGNAL DISPLAY
DISPLAY 3D MAP
162
ADD MARKER FOR:
STEERABLE TIP
LINEAR LESION
VALVE
SEPTUM
RSPV
LATERAL
156
3D MANIPULATORS
XY
ZOOM
ROTATE
158
ORIENT TO:
AP
RAO
LAO
LATERAL
160
REAL TIME
CS REF
RV APEX
LINEAR LESION CATHETER
BASKET
STEERABLE
JOURNAL WINDOW

FIG. 31

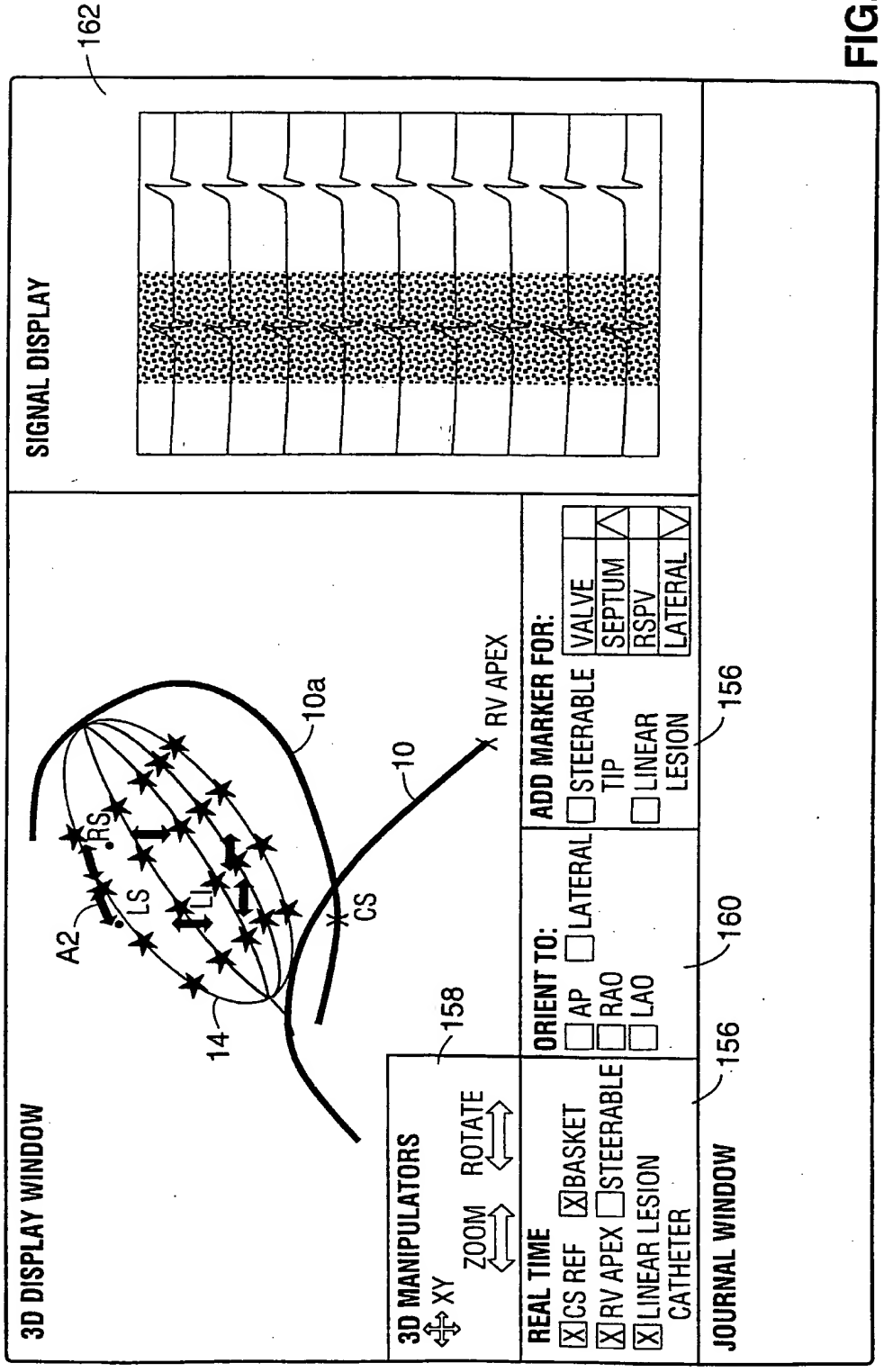
3D DISPLAY WINDOW
SIGNAL DISPLAY
162
3D MANIPULATORS
XY
ZOOM
ROTATE
158
REAL TIME
CS REF
BASKET
RV APEX
STEERABLE
LINEAR LESION
CATHETER
156
ORIENT TO:
AP
LATERAL
RAO
LAO
160
ADD MARKER FOR:
STEERABLE TIP
LINEAR LESION
VALVE
SEPTUM
RSPV
LATERAL
156
JOURNAL WINDOW
A2
RS
LS
LI
CS
RV APEX
10
10a
14

FIG. 32

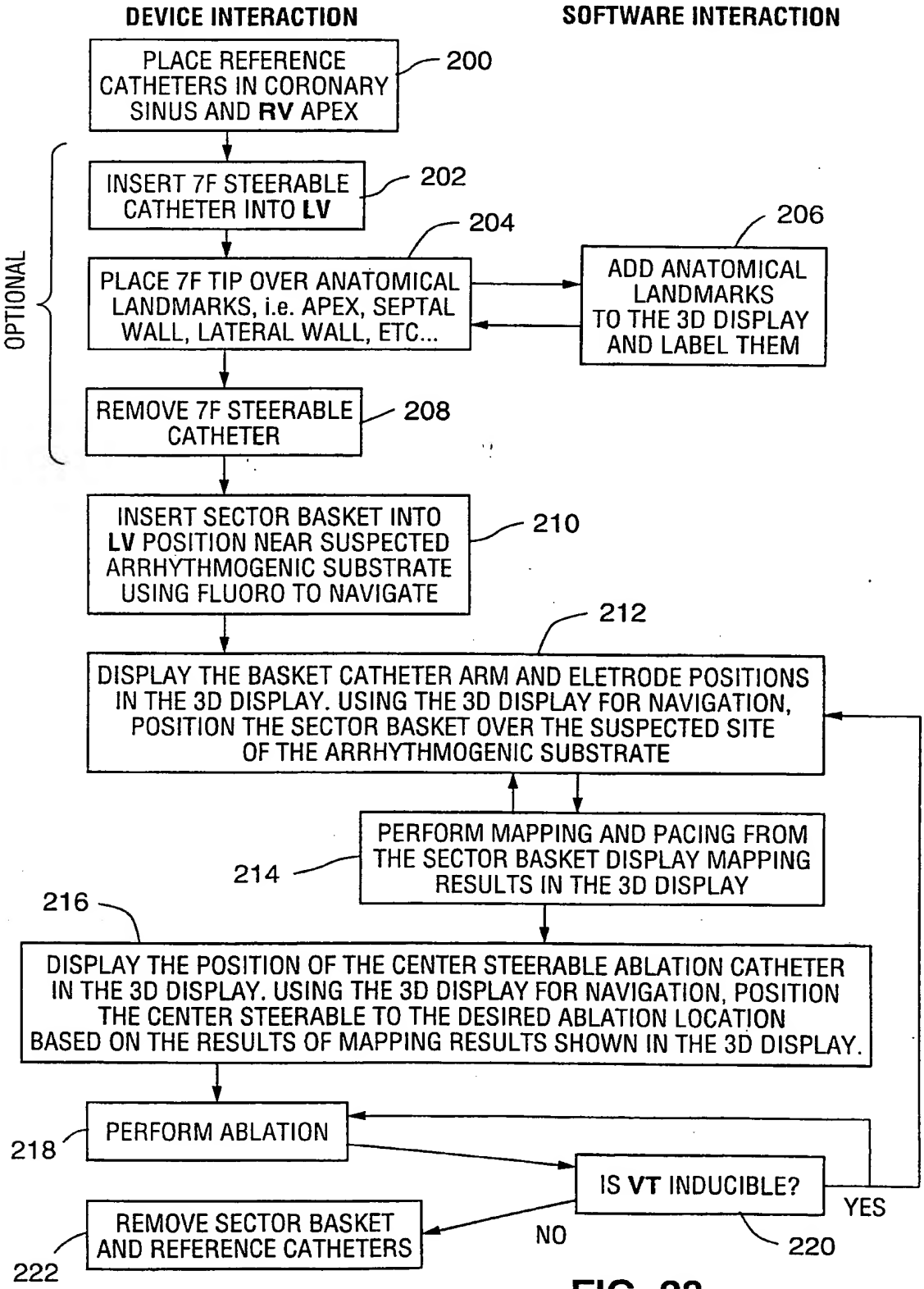
DEVICE INTERACTION
SOFTWARE INTERACTION
PLACE REFERENCE CATHETERS IN CORONARY SINUS AND RV APEX
200
INSERT 7F STEERABLE CATHETER INTO LV
202
204
206
OPTIONAL
PLACE 7F TIP OVER ANATOMICAL LANDMARKS, i.e. APEX, SEPTAL WALL, LATERAL WALL, ETC...
ADD ANATOMICAL LANDMARKS TO THE 3D DISPLAY AND LABEL THEM
REMOVE 7F STEERABLE CATHETER
208
INSERT SECTOR BASKET INTO LV POSITION NEAR SUSPECTED ARRHYTHMOGENIC SUBSTRATE USING FLUORO TO NAVIGATE
210
212
DISPLAY THE BASKET CATHETER ARM AND ELETRODE POSITIONS IN THE 3D DISPLAY. USING THE 3D DISPLAY FOR NAVIGATION, POSITION THE SECTOR BASKET OVER THE SUSPECTED SITE OF THE ARRHYTHMOGENIC SUBSTRATE
PERFORM MAPPING AND PACING FROM THE SECTOR BASKET DISPLAY MAPPING RESULTS IN THE 3D DISPLAY
214
216
DISPLAY THE POSITION OF THE CENTER STEERABLE ABLATION CATHETER IN THE 3D DISPLAY. USING THE 3D DISPLAY FOR NAVIGATION, POSITION THE CENTER STEERABLE TO THE DESIRED ABLATION LOCATION BASED ON THE RESULTS OF MAPPING RESULTS SHOWN IN THE 3D DISPLAY.
PERFORM ABLATION
218
IS VT INDUCIBLE?
YES
NO
220
REMOVE SECTOR BASKET AND REFERENCE CATHETERS
222

FIG. 33

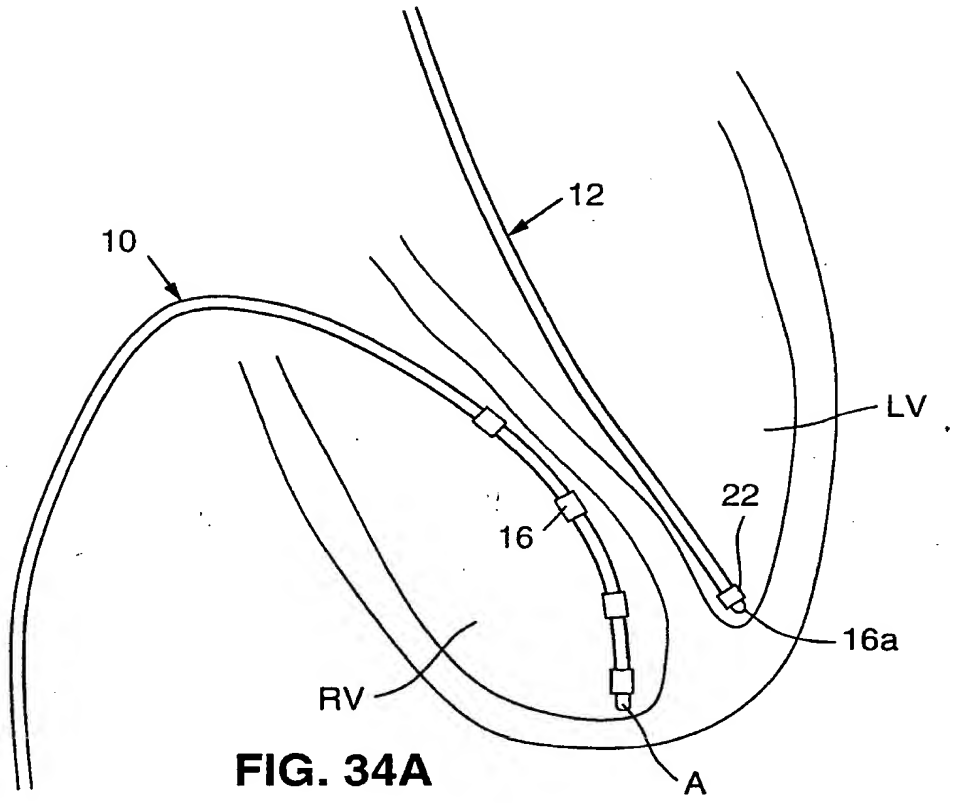

FIG. 34A

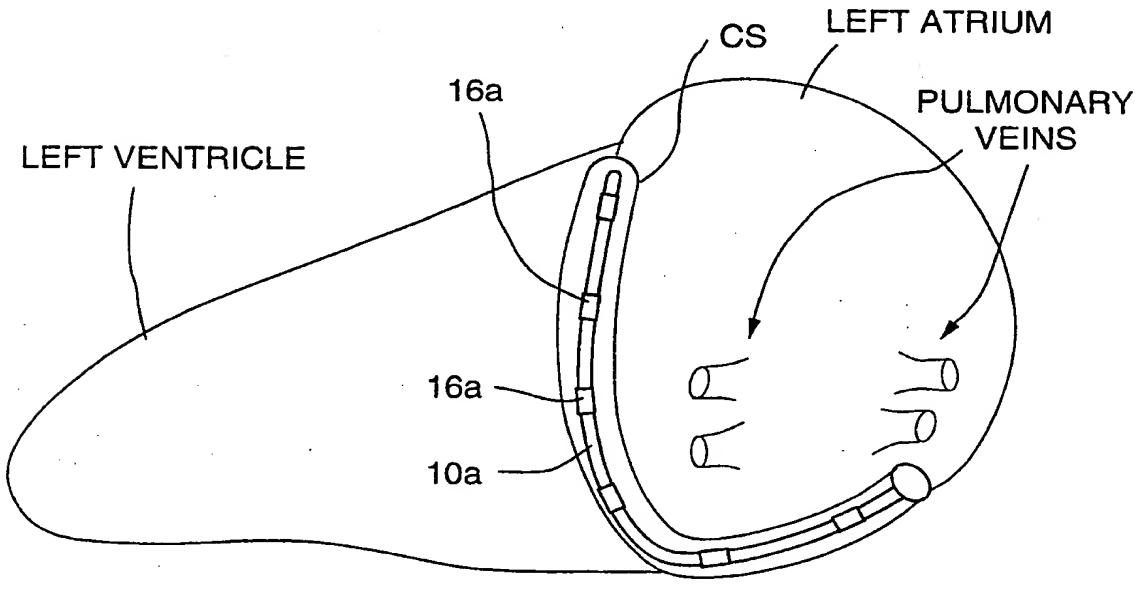

FIG. 34B

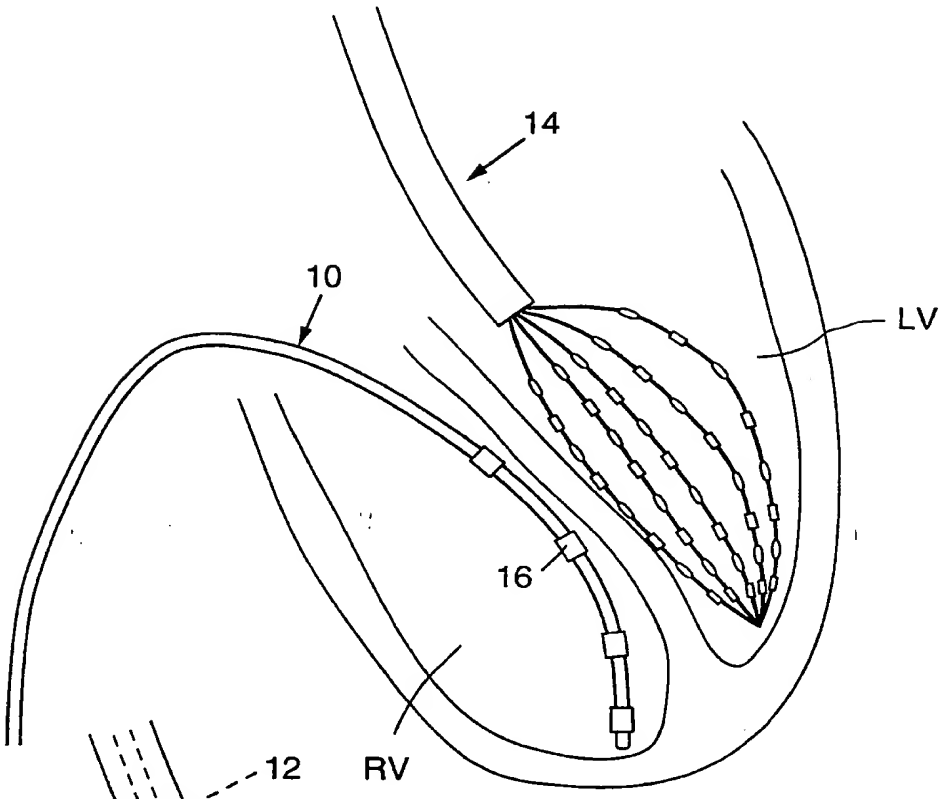

FIG. 34C

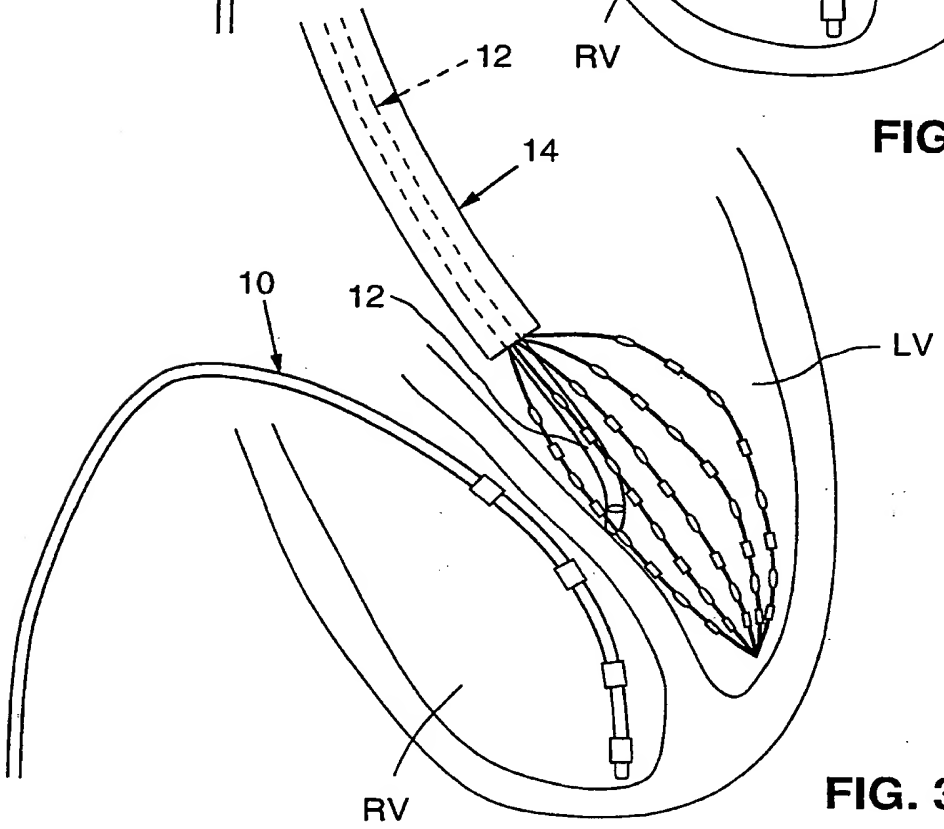

FIG. 34D

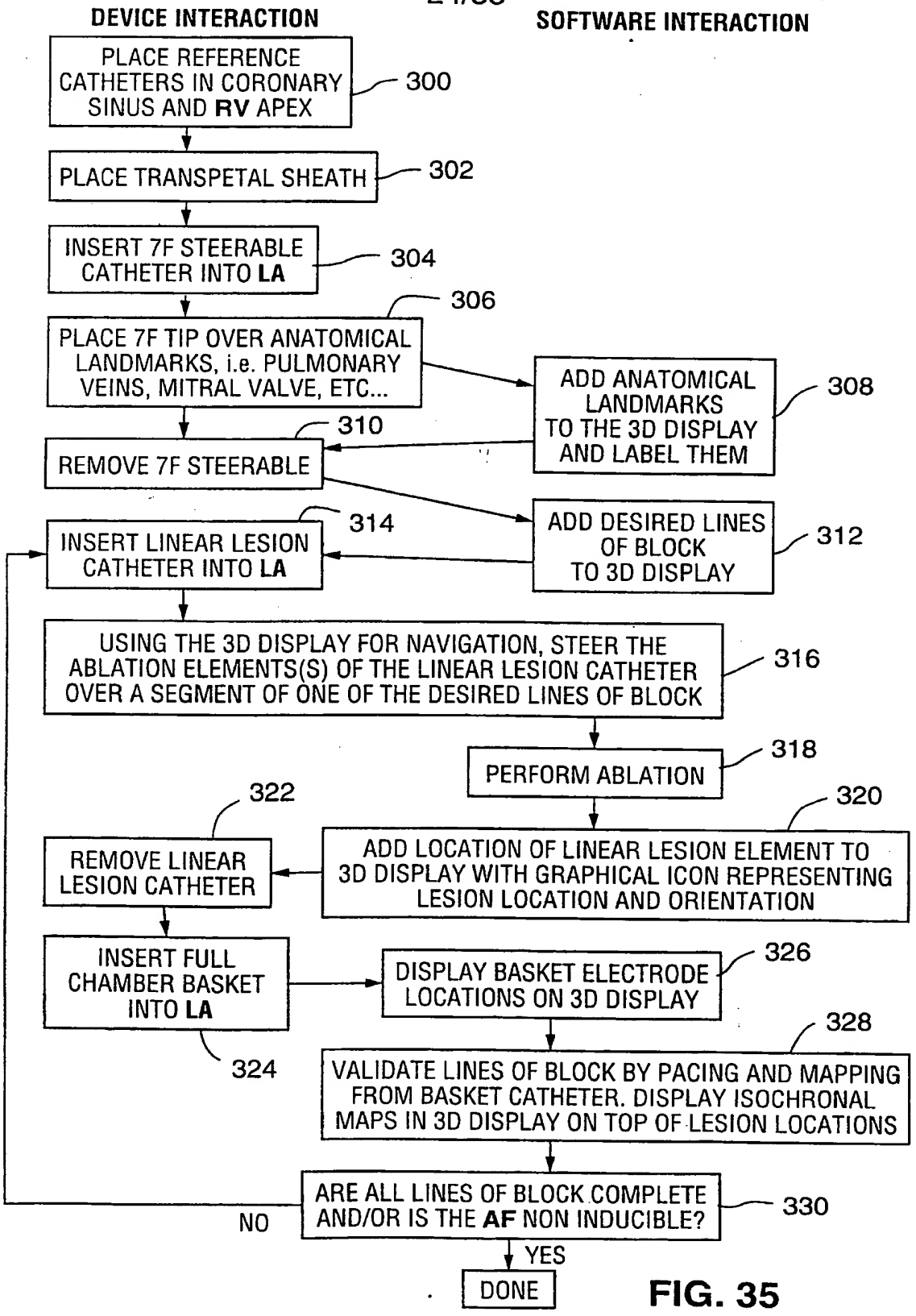
DEVICE INTERACTION
SOFTWARE INTERACTION
PLACE REFERENCE CATHETERS IN CORONARY SINUS AND RV APEX
300
PLACE TRANSPETAL SHEATH
302
INSERT 7F STEERABLE CATHETER INTO LA
304
306
PLACE 7F TIP OVER ANATOMICAL LANDMARKS, i.e. PULMONARY VEINS, MITRAL VALVE, ETC...
ADD ANATOMICAL LANDMARKS TO THE 3D DISPLAY AND LABEL THEM
308
310
REMOVE 7F STEERABLE
ADD DESIRED LINES OF BLOCK TO 3D DISPLAY
312
314
INSERT LINEAR LESION CATHETER INTO LA
USING THE 3D DISPLAY FOR NAVIGATION, STEER THE ABLATION ELEMENTS(S) OF THE LINEAR LESION CATHETER OVER A SEGMENT OF ONE OF THE DESIRED LINES OF BLOCK
316
PERFORM ABLATION
318
322
320
REMOVE LINEAR LESION CATHETER
ADD LOCATION OF LINEAR LESION ELEMENT TO 3D DISPLAY WITH GRAPHICAL ICON REPRESENTING LESION LOCATION AND ORIENTATION
INSERT FULL CHAMBER BASKET INTO LA
DISPLAY BASKET ELECTRODE LOCATIONS ON 3D DISPLAY
326
328
324
VALIDATE LINES OF BLOCK BY PACING AND MAPPING FROM BASKET CATHETER. DISPLAY ISOCHRONAL MAPS IN 3D DISPLAY ON TOP OF LESION LOCATIONS
ARE ALL LINES OF BLOCK COMPLETE AND/OR IS THE AF NON INDUCIBLE?
330
NO
YES
DONE

FIG. 35

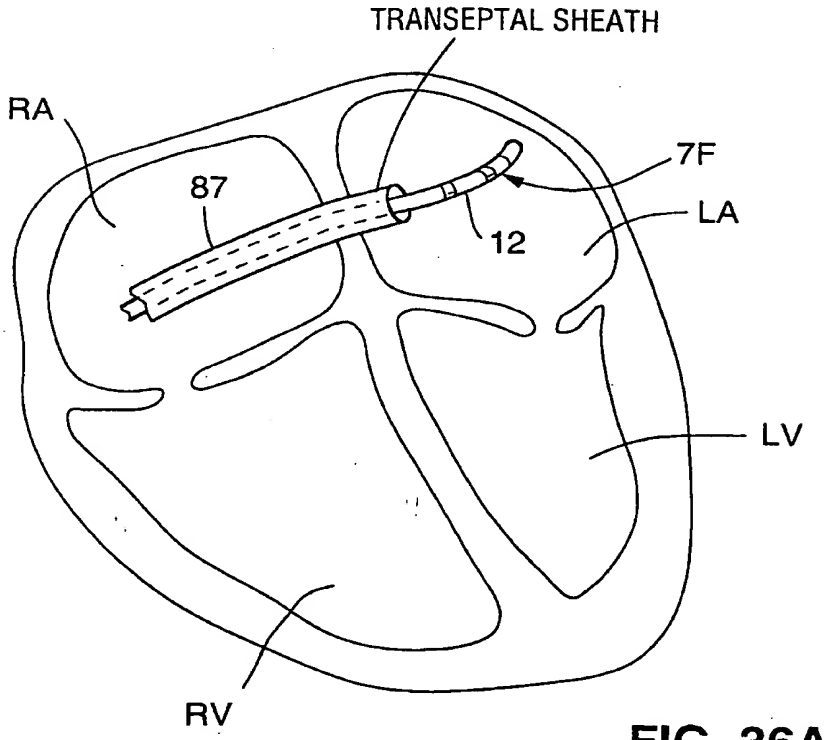

FIG. 36A

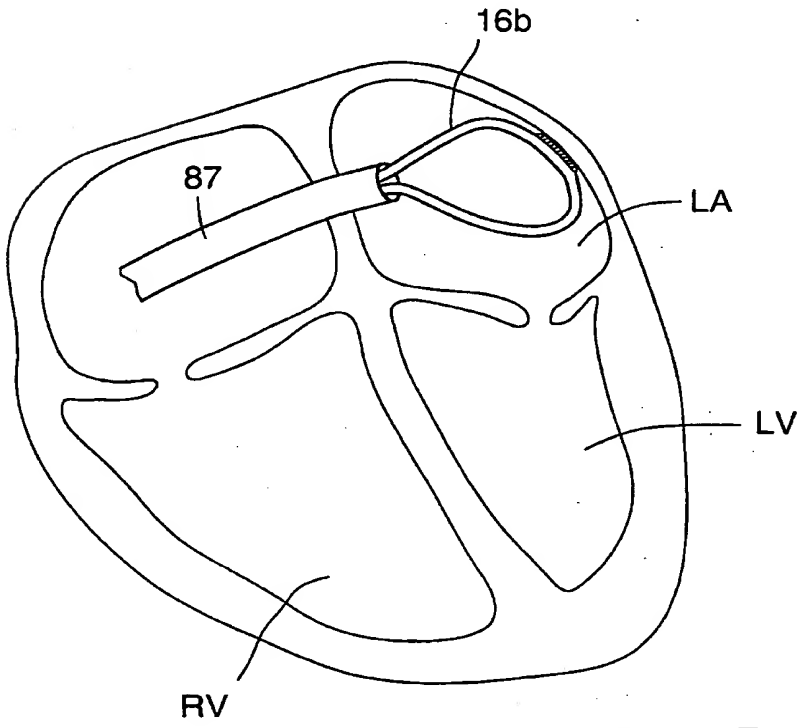

FIG. 36B

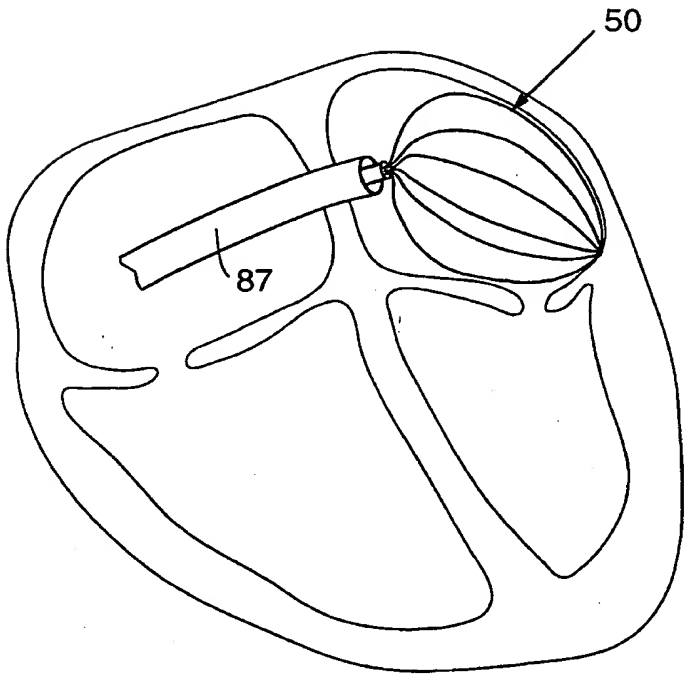

FIG. 36C

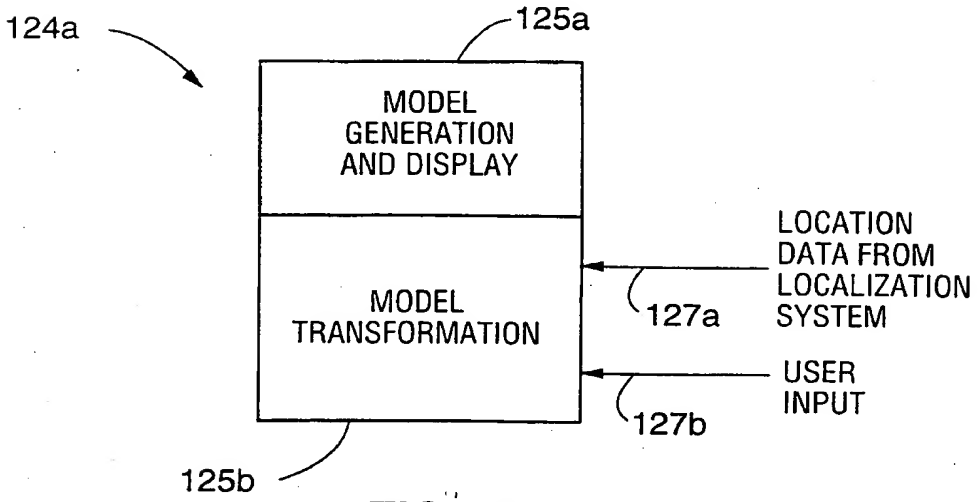
124a
125a
MODEL GENERATION AND DISPLAY
MODEL TRANSFORMATION
LOCATION DATA FROM LOCALIZATION SYSTEM
127a
USER INPUT
127b
125b

FIG. 37

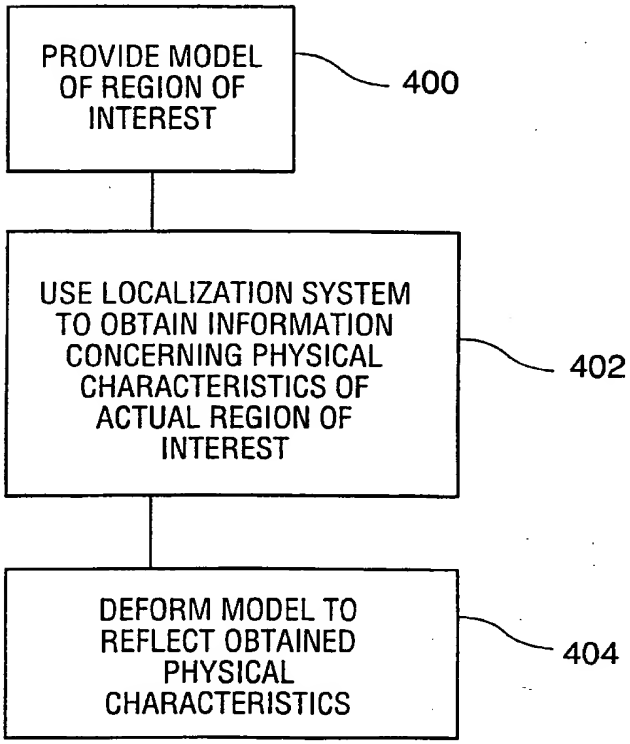
PROVIDE MODEL OF REGION OF INTEREST
400
USE LOCALIZATION SYSTEM TO OBTAIN INFORMATION CONCERNING PHYSICAL CHARACTERISTICS OF ACTUAL REGION OF INTEREST
402
DEFORM MODEL TO REFLECT OBTAINED PHYSICAL CHARACTERISTICS
404

FIG. 38

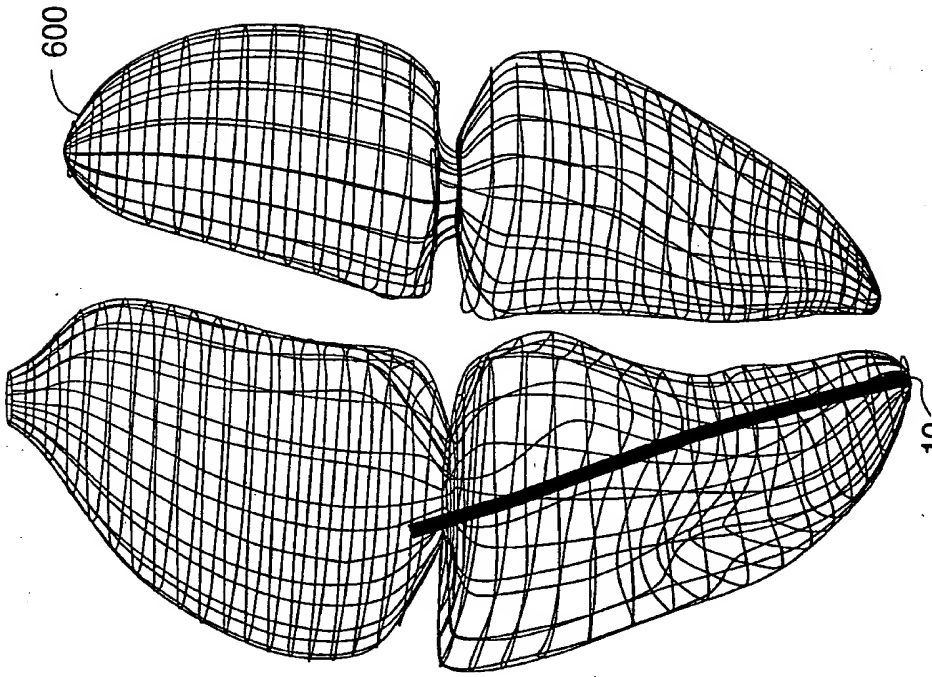

FIG. 39B

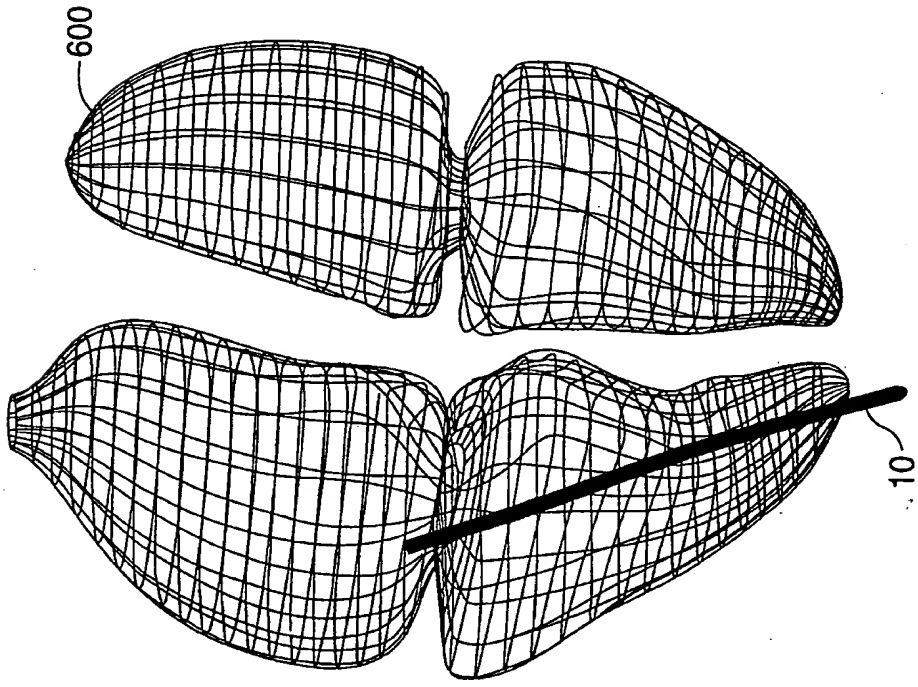

FIG. 39A

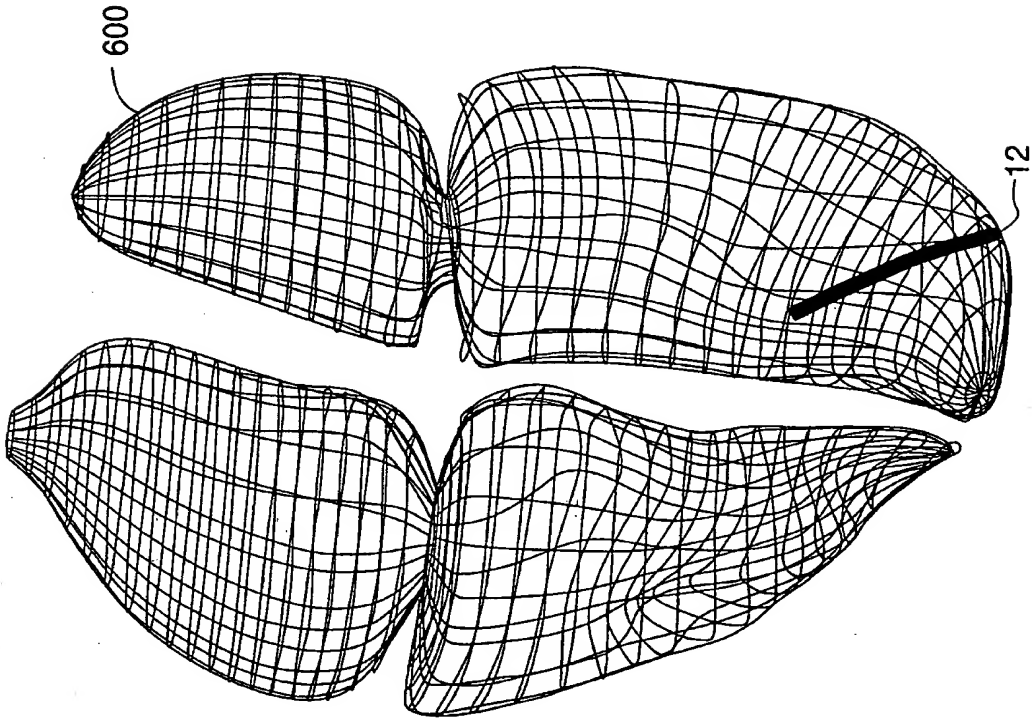

FIG. 40B

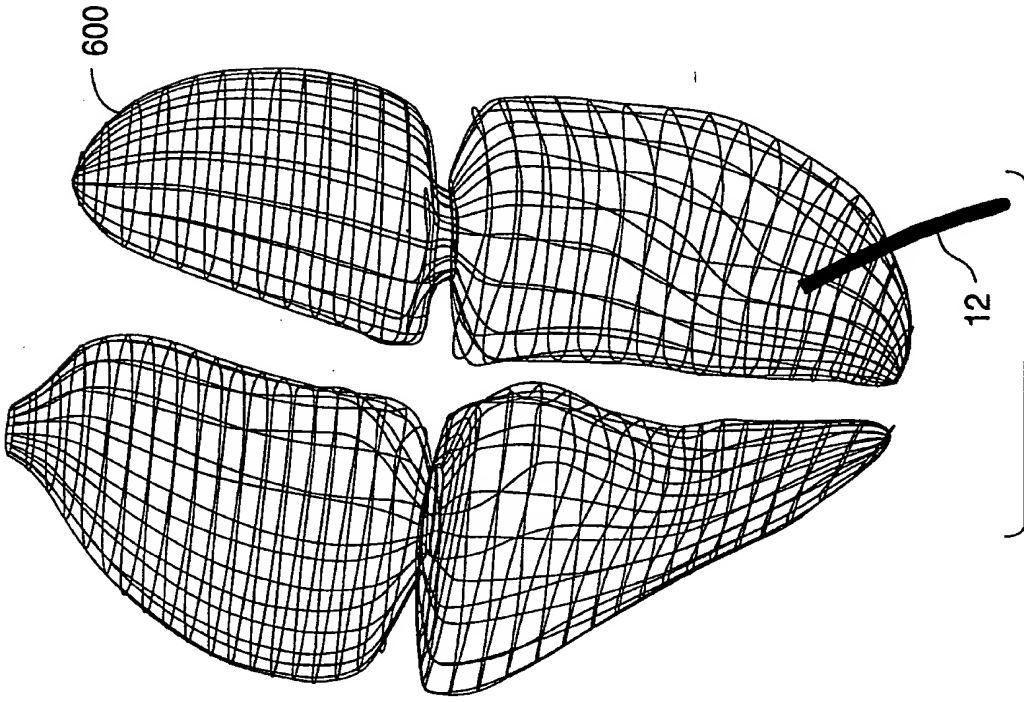

FIG. 40A

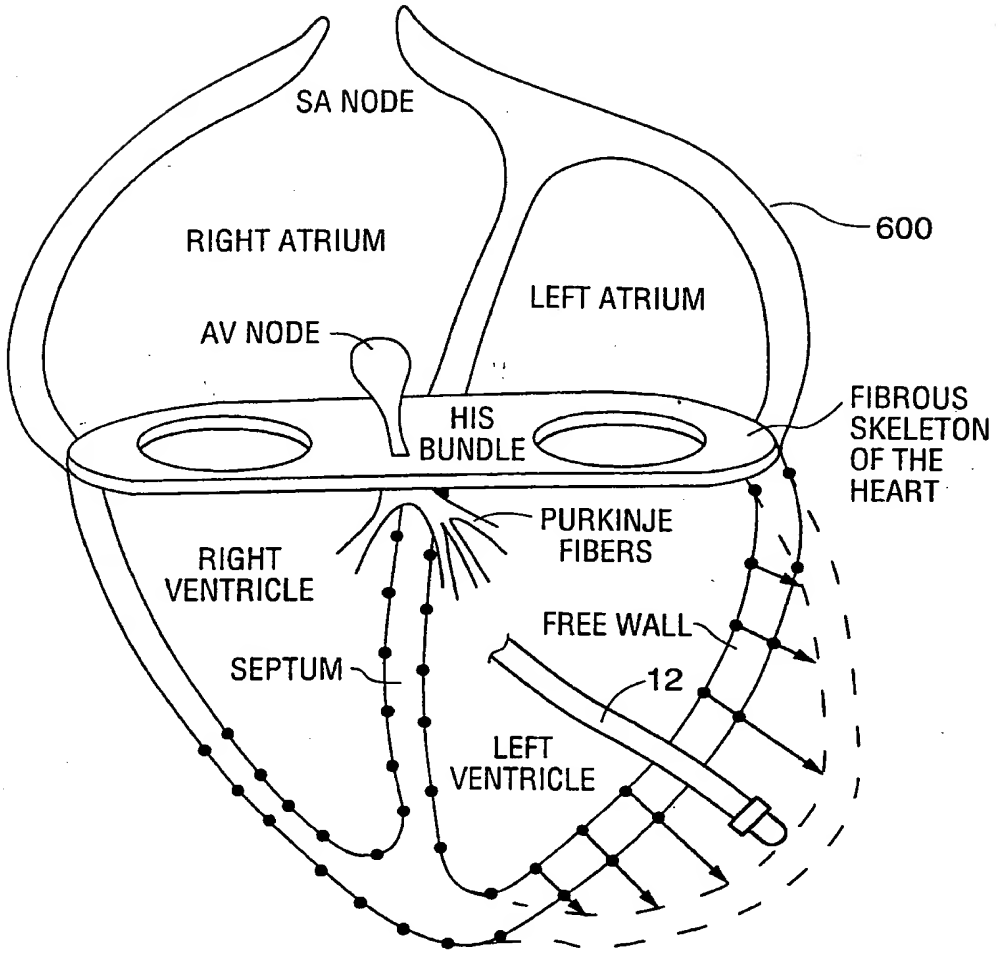
SA NODE
RIGHT ATRIUM
600
LEFT ATRIUM
AV NODE
HIS BUNDLE
FIBROUS SKELETON OF THE HEART
PURKINJE FIBERS
RIGHT VENTRICLE
FREE WALL
SEPTUM
12
LEFT VENTRICLE

FIG. 40C

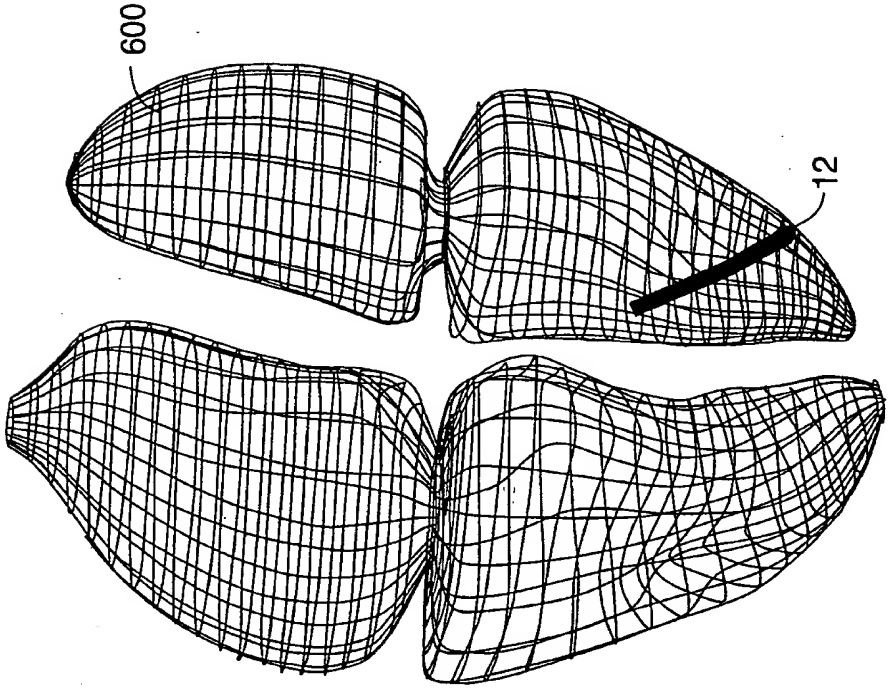

FIG. 41B

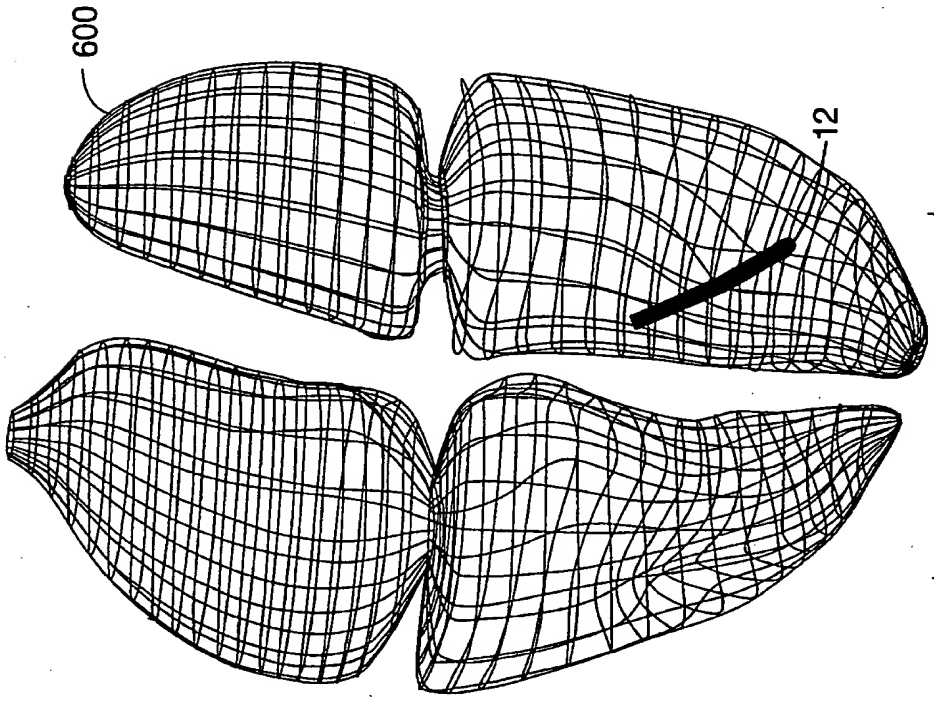

FIG. 41A

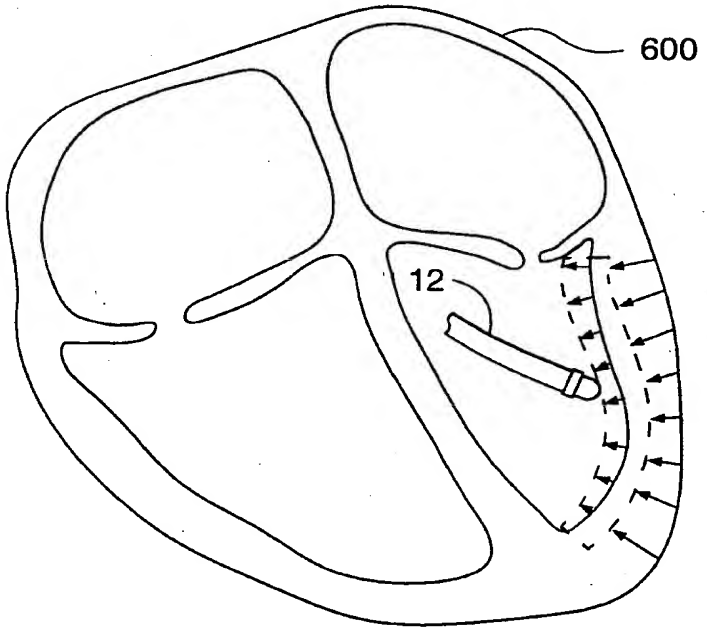

FIG. 41C

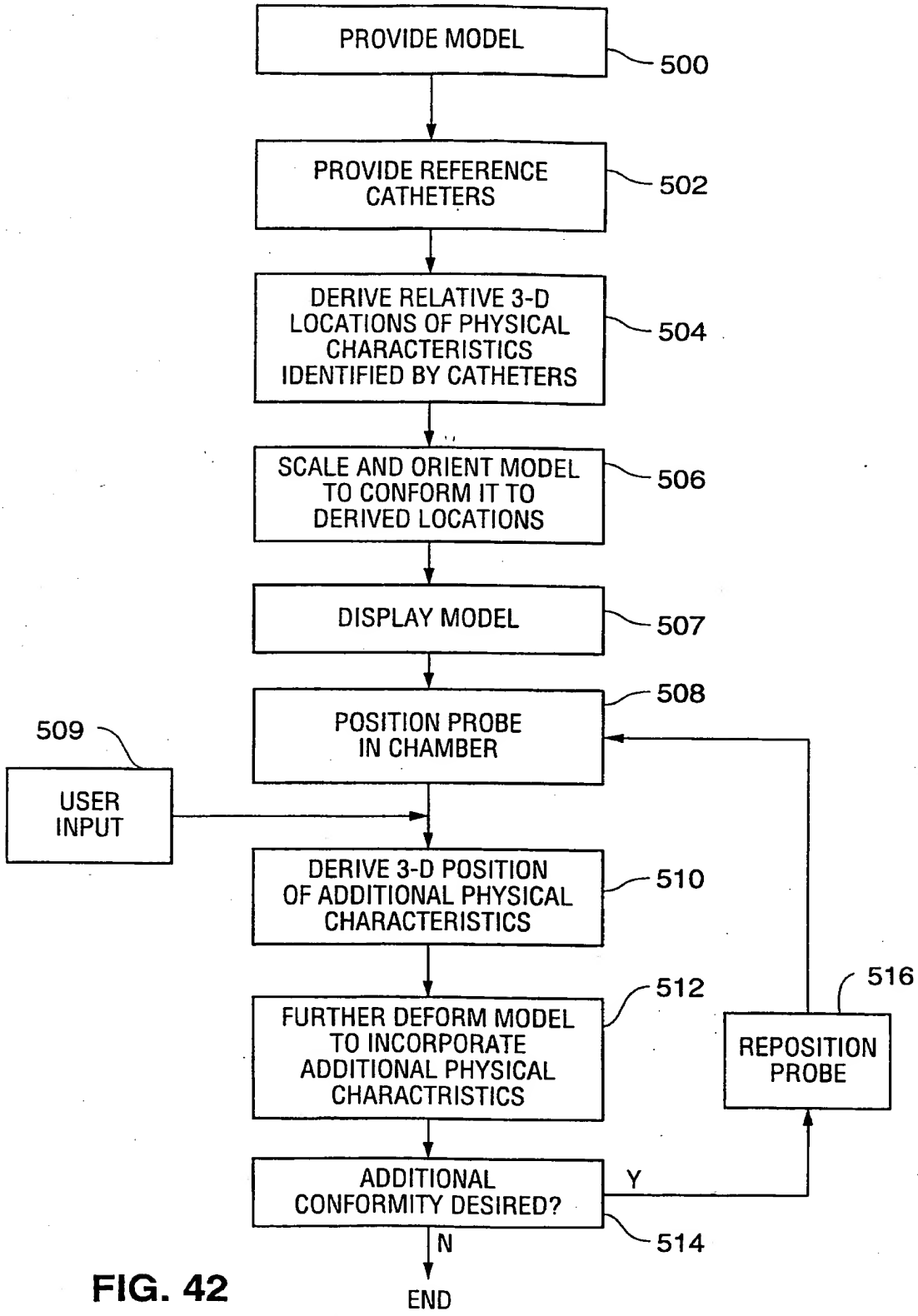
PROVIDE MODEL
500
PROVIDE REFERENCE CATHETERS
502
DERIVE RELATIVE 3-D LOCATIONS OF PHYSICAL CHARACTERISTICS IDENTIFIED BY CATHETERS
504
SCALE AND ORIENT MODEL TO CONFORM IT TO DERIVED LOCATIONS
506
DISPLAY MODEL
507
POSITION PROBE IN CHAMBER
508
509
USER INPUT
DERIVE 3-D POSITION OF ADDITIONAL PHYSICAL CHARACTERISTICS
510
FURTHER DEFORM MODEL TO INCORPORATE ADDITIONAL PHYSICAL CHARACTRISTICS
512
516
REPOSITION PROBE
ADDITIONAL CONFORMITY DESIRED?
Y
N
514
END

FIG. 42